SAE Journal

APRIL 1959

IN THIS ISSUE . . .

Published by The Society of Automotive Engineers

2 reasons why engines get more power protection from Perfect Circle

1. PERFECT CIRCLE CHROME RINGS

solve problem of excessive oil consumption past pistons!

P C chrome piston rings are the finest obtainable! Top rings and oil rings are plated with thick, solid chrome. Entire area of ring travel gets complete wear protection, more than doubling life of cylinders, rings, pistons. No tedious break-in is necessary because rings are pre-seated at factory.

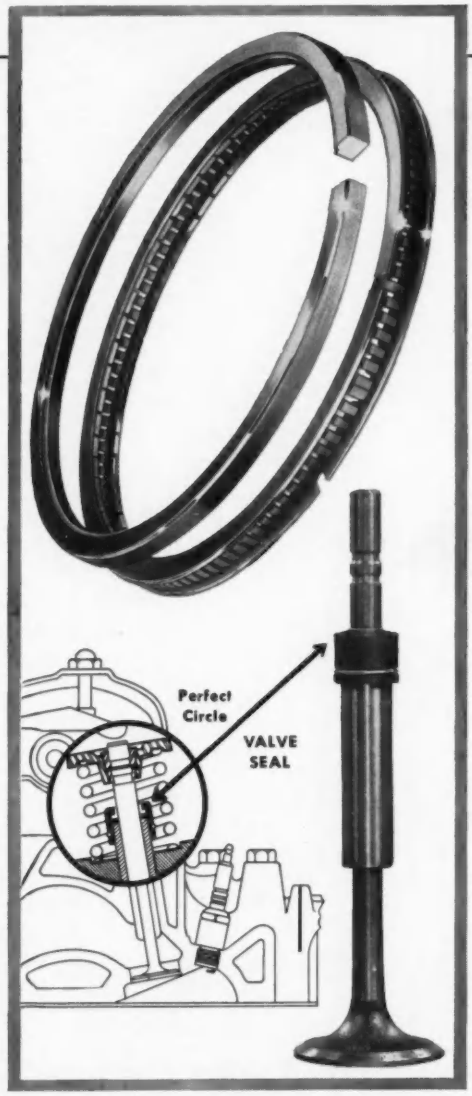
SPECIFY P C CHROME RINGS for thousands of extra miles of power protection with positive oil control!

2. PERFECT CIRCLE VALVE SEALS

solve problem of excessive oil consumption past valves!

New overhead valve engines develop higher compression pressures...and higher deceleration vacuum. Increased vacuum draws oil through loose or worn valve guides. Avoid this oil loss with new Perfect Circle Valve Seals!

SPECIFY PERFECT CIRCLE VALVE SEALS to control oil loss through valve guides in overhead valve engines.



PERFECT CIRCLE

PISTON RINGS AND POWER SERVICE PRODUCTS

Hagerstown, Indiana — Don Mills, Ontario, Canada

SAE Journal

Society of Automotive Engineers

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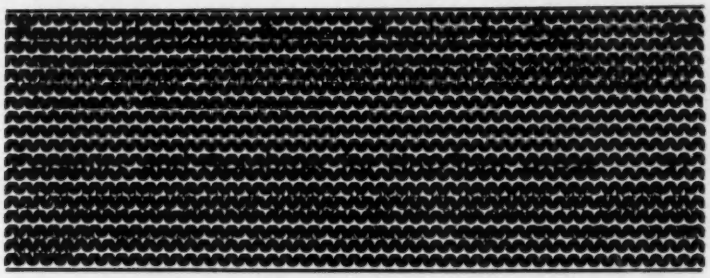

To order papers on which articles are based, see p. 6.

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To order papers on which articles are based, see p. 6.

Departments

READERSHIP Editorial RESEARCH

ADVANCED DESIGN PISTONS

By GILLETT AND EATON

for Longer Heavy Duty Service

TROUBLE-FREE with thousands in use

★ Low initial cost ★ Low cost per mile

★ Amazing increase in piston life

★ Maintains new engine power and performance

G and E WIRE INSERTS PUT CAST IRON WEAR IN TOP RING GROOVE

G and E Wire Insert Piston before machining (left) and after ring grooves are cut (right) showing how the steel wire forms a tough wear-resisting surface on both faces of top ring groove. The patented ferrous plug molded in the head (for diesel pistons) prevents burning through head and lengthens diesel piston life!

With the thousands of G and E "Wire Insert" Pistons in use for periods up to 3 years—a phenomenal record for trouble-free operation has been established. The "Wire Insert" greatly reduces top ring groove wear and increases piston life.

The "Wire Insert" piston design—exclusive with G and E—combines all the advantages of aluminum alloy pistons with the long life of steel in the top ring groove lands. No noticeable increase in weight—unequalled for rapid heat flow—and at low cost.

A pre-shaped steel wire is cast into the piston where the top ring is located. When the grooves are machined, the closely spaced wire surfaces form hard bearing areas on top and bottom faces of the groove. Result—reduced ring land wear, longer piston life at lower cost.

as LIGHT as aluminum . . . wears LIKE IRON

VANASIL*

"OIL-ABSORBING" PISTONS FOR GASOLINE AND DIESEL ENGINES

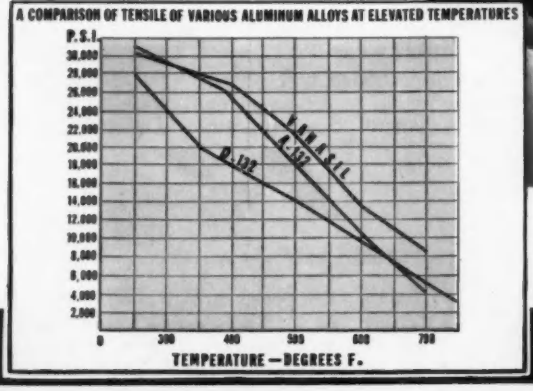
*Gillett & Eaton's trademark for a Hyper-eutectic silicon aluminum alloy

VANASIL Pistons have repeatedly run way over 200,000 miles with only .002" to .005" wear on the top ring grooves. On-the-road ring breakdowns caused by badly worn grooves are almost eliminated because *Vanasil Pistons reduce top ring groove wear up to 75%!* Nothing else compares with the genuine G & E Vanasil—the original Hyper-eutectic silicon alloy, proven by 19 years of use.

You Get ALL These Advantages Only In GENUINE VANASIL PISTONS

G & E PROVED Hyper-eutectic Silicon Alluminum Alloy

1. LIGHT WEIGHT—Same as other aluminum alloys.
2. SCORING, SCUFFING MINIMIZED—Because of "Oil Absorbing" microscopic porous texture.
3. LONGER LIFE—30% less friction—30% harder. Greater "hot strength"—see chart at right.
4. TOP RING—Breakage virtually eliminated because of reduced ring groove wear.
5. LOW EXPANSION—Characteristics of Cast Iron.
6. CLOSE CLEARANCES—Fitted with Cast Iron Clearances.
7. SOLID SKIRT DESIGN—No expansion devices required.
8. HIGH HEAT CONDUCTIVITY—Similar to other aluminum alloys.
9. PLATING—No tin or other break-in coating required.



Write for complete information and prices on Gillett and Eaton's Wire Insert and Vanasil longer lived pistons.

"Our 91st Year"

GILLETT and EATON, Inc. 853 DOUGHTY STREET LAKE CITY, MINNESOTA

Briefs of SAE PAPERS

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Readers Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.

AIRCRAFT

Reduced Cooling Requirements Through Integrated Design, P. E. PETTY. Paper No. S129. Cooling problems of high performance aircraft, fighters, missiles, and bombers, as they affect crew and electronic systems; concepts used in MIL-E-5400 and MIL-E-19600; cooling requirements, characteristics, and sources; how both systems can be integrated into single system if cooling characteristics are designed to be compatible, matched to aircraft performance envelope and system is installed so as to utilize every available btu before discharging cooling medium overboard.

Space Trajectories and Flight Test Objectives, J. W. LUECHT. Paper No. No. 5S. Critical examination of relationship between space trajectories and flight test objectives from engineering point of view; state of development of space vehicle system cannot be measured in terms of trajectories flown; important occurrences are internal rather than external to system; abbreviated flight test program requires integrated plan encompassing both flight and laboratory tests and systems analysis; four basic aims of test program.

Trends in Support Equipment Systems, P. J. BURR. Paper No. 7T. Bureau of Aeronautics' approach to criteria for selection and operation of ground support systems required to perform maintenance and servicing of jet propelled military aircraft and missile systems; interdependent factors to consider are human adaptability, safety, simplicity, universality, standardization, mobility, quality, and usability; need for evaluation of possible future aeronautical growth patterns.

Future of Airline Ground Transportation, H. J. DeGRAFF. Paper No. 15S. Transportation services and problems from viewpoint of Airline Ground Transportation Assn; organization and transportation patterns; discussion of problems divided into legal and operational aspects; communications and mutual understanding; possibilities of helicopters or monorails; measures adopted to improve airport ground transportation in immediate future; it is believed that airport to metropolitan transportation will long be served by usual surface vehicles.

Airline Ground Equipment Functional Requirements and Design, W. H. PITT. Paper No. 18R. Problems associated with functioning of ground support equipment, its development and design; problem can be effectively handled through use of inexpensive mockups, or development and manufacture of prototype unit; latter manufactured to functional specification is also used to make certain that unit meets specification, will do its job efficiently and that it is acceptable to using department; illustrations show various stages of development.

Electrical Ground Power for Commercial Jet Aircraft, R. L. FRANTZ. Paper No. 18S. Discussion of 400-cycle a-c ground power requirements for servicing Lockheed Electra, Douglas DC-8, Convair 600 and 880, and Boeing 707 and 720; d-c ground power for Fokker F-27, Vickers Viscount, Caravelle, Comet IV, and Bristol Britannia aircraft; subjects treated include: airline specifications, generator charac-

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Briefs of SAE PAPERS

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teristics, protective devices, ratings for various aircraft, type of prime mover—stationary or mobile; ground power for European jet aircraft.

Early Experience with Ground Equipment for B707, P. G. NEELSEN. Paper No. 18T. Approach taken by Ground Services of Pan American World Airways in development of procedures, techniques and acquisition of equipment and facilities for servicing turbo-jet aircraft; details of three different phases of ground servicing, namely, jet engine starting, refueling, and demineralized water handling; types of equipment used; refueling procedures developed in cooperation with Esso to cover peculiarities of jet and methods employed in underwing pressure refueling.

Aircraft Accident Investigation Techniques, M. V. CLARKE, I. H. HOOVER. Paper No. 20R. Civil Aeronautics Board's methods in study of accidents involving transport aircraft; fundamental techniques, particularly those of engineering nature applied to actual accidents; examination of airframe wreckage; functions of Operations Group responsible for developing facts relating to history of flight, crew and probable flight path; witness study; radio, electrical equipment, and power plant study; use of structural mockup of specific sections of aircraft.

FUELS & LUBRICANTS

300 Horsepower Gasoline, D. J. ROSSELLE. Paper No. S136. Summary of problems encountered and solved in development of gasoline to provide troublefree, economical performance of high output engines operating under extremes of low duty, stop-and-go, congested city driving, and high speed; combustion problems such as surface ignition and rumble; spark plug fouling, carburetor icing, vapor lock, carburetor deposits and other factors.

New Fluorester Lubricants for High Temperature Applications, E. C. BALLARD, E. E. SOMMERS. Paper No. 9R. Requirements of turbojet engine lubrication; problems of relating chemical structure to physical properties and performance of highly fluorinated ester lubricants; discussion of results of experimental program with respect to oxidation stability, thermal, and hydrolytic stability, physical properties of esters; evaluation of fluoroalkyl camphorate and pyromelliate; additional field evaluation is needed. 22 refs.

GROUND VEHICLES

Checking Air Brakes in Preventive Maintenance, C. R. HERRING. Paper No. 20S. Recommendations made for prolonging maintenance free operation of air system; keeping breakaway kit and emergency portion of trailer valve in truck and trailer brakes operable; importance of brake balance; variations in air pressure delivery to brake chambers due to variance in low pressure and rapid high pressure deliveries, and variance because of reservoir capacities; checking variations with Duplex Gage.

Instrumentation for Fleet Maintenance, A. T. CASHEL. Paper No. 20T. Objective of fleet maintenance program; how to achieve effective cost control; plan of instrumentation in fleet maintenance involves use of trained technicians and adequate testing equipment, to determine maintenance needs; maintenance procedures; complete diagnosis approach is impractical from both time and cost standpoint; testing of various areas of ignition system and fuel delivery system which affect engine performance and of other components is proposed; test procedure.

Alignment and Balance of Wheels for Maintenance, Safety, and Comfort, C. W. MacMILLAN. Paper No. 20U. Wheel alignment practice consists of measuring and restoring designed angular relationship of steering and suspension components; processes of alignment maintenance require use of correctly designed instruments or gages to measure wheel toe, and angles of camber, caster, steering axis, and turn-

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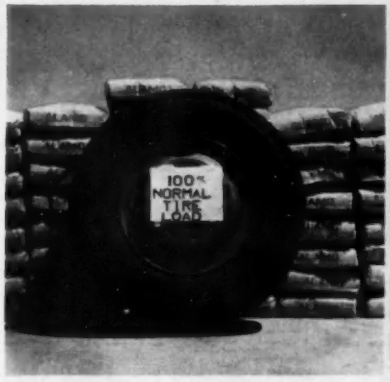
MORE TIRE POWER means LESS TREAD WEAR



START WITH AN OVERLOAD

The illustration above shows a 100% load. In an independent test, trucks equipped with nylon tires and tires containing TYREX viscose cord started with *120%* loads . . and went up from there!

ADD INTENSE HEAT

Tire and roadbed temperatures were checked carefully. Although road temperatures soared to 139°, tires made with TYREX viscose cord more than adequately met these adverse temperature conditions.

THEN PILE ON MORE WEIGHT

Tires containing TYREX viscose tire cord traveled over 20,000 miles at up to 40% overloads without any failures. Then the overload was upped to 50% above Tire and Rim Standards.

SOME CAN'T TAKE IT

Before the test ended some tires had failed from separation . . . could not be used or recapped. Tires containing TYREX viscose cord went on to *30,000* miles . . . *had* tread left and *were* recappable.

. . . BUT TYREX CAN AND DID!

When the testing was completed, measurements of all the tires showed: the rate of tread wear of *10 ply* tires made with TYREX viscose tire cord was up to 21.7% better than *12 ply* nylon tires.

TYREX*

TIRES MADE WITH TYREX VISCOSE TIRE CORD DELIVER UP TO 21.7% BETTER TREAD WEAR

Give your customers more tire power with TYREX viscose tire cord—the tough new cord that makes *any* tire run cooler, softer, quieter and safer . . . without flat spotting. These advantages make selling a lot easier.

TYREX INC., EMPIRE STATE BLDG., NEW YORK 1, N. Y.

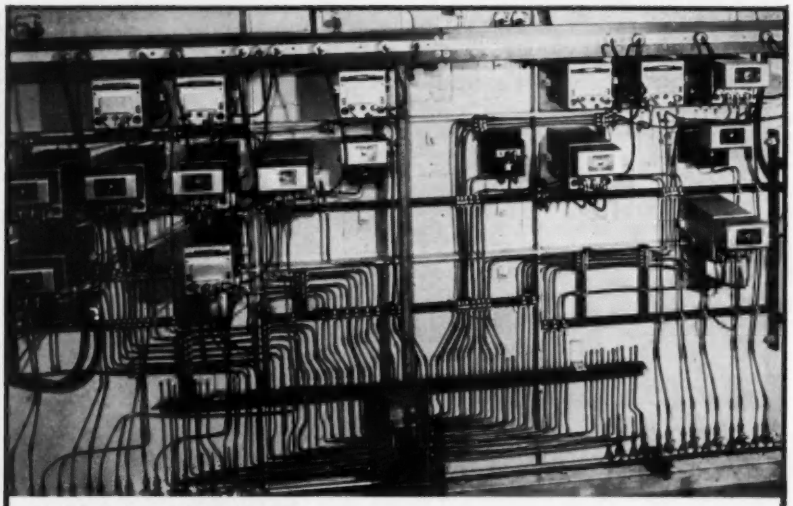
**TYREX is a certification mark of Tyrex Inc., for viscose tire cord and yarn. TYREX viscose tire cord and yarn are also produced and available in Canada.*

Plaskon Nylon News

A round-up of recent happenings in type-6 nylon, including new applications... and some economics for extruders to ponder.

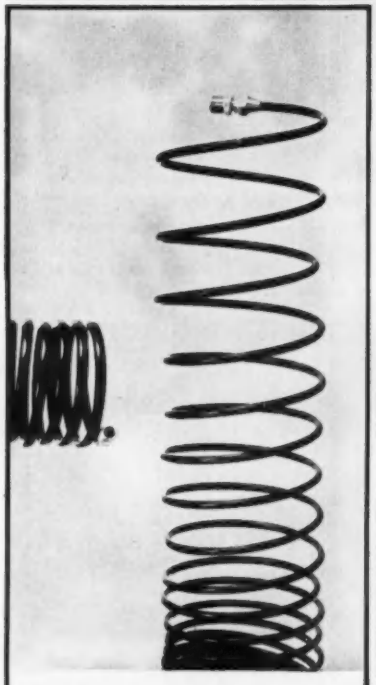
ECONOMY IN EXTRUSIONS

The question, "Is the scrap reusable?" can make or break the profit picture of any extruding operation. PLASKON Nylon Extrusion Compound 8205 maintains high-melt viscosity through successive regrinds. Scrap can be re-extruded several times without loss of basic properties. This scrap re-use often gives a sharp competitive advantage to users of PLASKON 8205.



INSTRUMENTATION

Color-coded nylon tubing replaces copper in control panel at Allied Chemical's phthalonitrile plant, Edgewater, N. J. Nylon's advantages: 50% less in cost, greater corrosion resistance, easily color-coded.

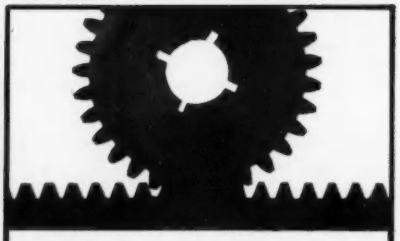


TOUGH AIR HOSE

For use with pneumatic tools, this lightweight "Nycoil" hose is extruded from PLASKON Nylon. It's tough, heat-resistant, unaffected by hydrocarbons . . . has permanent recoil action.

FOOTBALL CLEATS

Molded of PLASKON Nylon, these cleats outwear other types by a factor of 5 to 10. Their safety and durability suggest other possible applications in sports equipment.



GEAR AND RACK

Type-6 nylon has higher impact resistance than other nylons. This advantage goes to work in a gear and rack molded of PLASKON Nylon and used in Scott Company lawnmowers. The parts are more durable than the metal ones they replace.

For further information, or technical assistance, write to our Nylon Product Development Department.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

For the Automotive Industry . . .

the big insulation news for 1959 is

JOHNS-MANVILLE FIBER GLASS

With L·O·F Glass Fibers Company joining the Johns-Manville family, your J-M representative can now supply you with quality J-M fiber glass insulations specifically designed for service in all types of vehicles—automobiles, trucks, trailers and busses.

These J-M fiber glass insulations are made from long, fine glass fibers that create *more* and *smaller* air cells. They provide:

- **Thermal efficiency**—the enormous number of tiny air cells form an unusually effective heat barrier, permit less thickness for most jobs
- **Sound absorption**—the multiplicity of sound traps soak up air-borne noise
- **Resiliency**—after compression, blankets spring back to original thickness
- **Tensile strength**—longer fibers produce blankets that will not pull apart in normal handling
- **Resistance to settling**—holds position when properly installed, resists vibration "shake-down"

. . . these insulations also offer lightness in weight, flexibility, resistance to fire, moisture, and deterioration.

In other industries, too—construction, appliances and equipment, textiles—buyers of fiber glass products will now be served by an enlarged field staff of J-M sales and technical personnel operating out of 56 sales offices . . . by expanded distribution facilities . . . by the addition of 7 strategically located plants and by expansion of research and development of fiber glass products.

Call your Johns-Manville representative or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ont.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

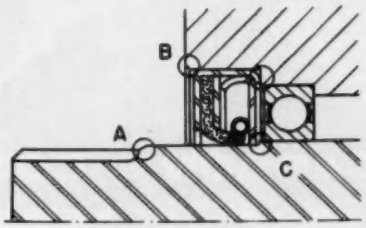
NATIONAL OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

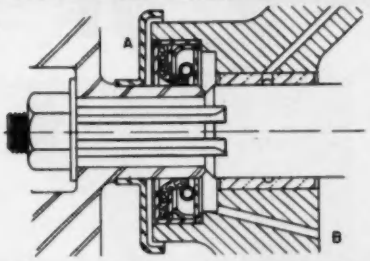
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



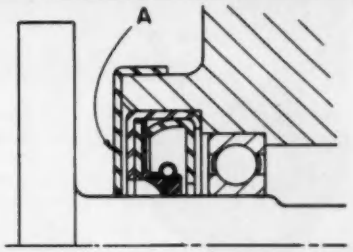
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



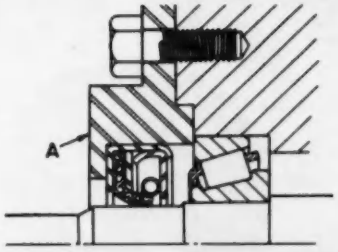
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.



INSUFFICIENT DEPTH TO MOUNT SEAL

Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

5207

TODAY'S ANTIFREEZE RESEARCH HERALDS NEW FORMULATIONS OF TOMORROW

Ever since the roaring twenties, which saw the development of the first ethylene glycol based antifreezes, Dow chemists have been researching the technical problems of the cooling system. Out of that research has come not only constant improvement in today's antifreezes, but hints of what may be in store for the cooling systems of the future.

When an experimental formulation proves out in the laboratory, it is exhaustively tested in banks of radiators, then run in fleet tests before being pronounced "ready for market".

This program at Midland has already helped produce the vastly improved antifreeze formulations of today, as America watched crude substances such as honey, molasses, salt and kerosene, once used to protect against freeze, give way to alcohol mixtures, then to ethylene glycol formulations, the misnamed "permanent" protective fluids.

The word "antifreeze" in Dow's vocabulary can mean any of a number of good things. Reason: engineers have differing ideas as to the relative importance of one or more of the several functions that a good antifreeze must perform. So, Dow will formulate antifreeze to company specifications. For example, Dow supplies automotive companies (for antifreeze fill on the assembly line) formulations that are prepared "on prescription". Or Dow will formulate according to the U.S. Government specifications. Or will furnish you with one of Dow's own formulations. Or will create entirely new formulations to meet particular requirements! That's antifreeze today—what of tomorrow?

What kind of cooling system research would a roving reporter see if he could wander freely through Dow's Automotive Chemicals Laboratories? Remarkable banks of automobile radiators, both conventional and sealed types, running simultaneously for long periods, to test present antifreeze formulations as well as new and experimental ones.

He would see engines with "windows"—thermocouples strategically placed throughout an engine—that make it possible to "see" temperature changes that occur anywhere in the engine, as different cooling system fluids are tested comparatively.

In a more experimental area of cooling system research, the reporter would see a task force at work on "boiling" or ebullient cooling, experimenting with new liquids that, when made to boil and vaporize, dissipate more heat than circulating water. When perfected, these new formulations will provide better cooling and may enable presently wasted engine heat to be utilized in driving a generator or a fan. But, more

importantly from the designer's point of view, they may permit radiator size to be reduced 15% to 20% while eliminating the need for a water pump.

What's ahead? Constantly improved conventional antifreezes, of course. And antifreezes to meet the demands of new engine metals and other near future engineering developments.

Working today to give tomorrow a better brake

When a vehicle weighing tons has to be stopped in seconds by a device weighing mere pounds, there's bound to be a big job for hydraulic fluids. And with the increasing weight and horsepower of modern automobiles, brake fluids are being called on for heavier and heavier service. These fluids must be compatible with many materials—rubber and various metals.

But the biggest problem of course is temperature tolerance. Higher and higher boiling points had to be achieved to withstand the heat generated by braking the greater weight of today's cars and the higher speeds possible in them. Dow research chemists with their special knowledge of glycols and polyglycols, working with automotive engineers, are meeting the challenge of mounting Fahrenheits offered by today's brakes. Dow's heavy duty brake fluid formulations have been the answer to many engineers' braking problems.

* * * *

For further information on the products discussed in this advertisement or on the Automotive Chemicals Section of Technical Service and Development, contact THE DOW CHEMICAL COMPANY, Midland, Michigan, Chemicals Sales Department 900EN-4

New TRANSMISSION LUBRICANTS make more leg room

He may be looking at a new car design ideal But this new high density fluid will have to run the gauntlet of a rigorous testing program before it will be ready for the road.

New synthetic transmission lubricants now under test at Dow are interesting to even the most exacting automotive engineers. The reason: They can open the way to major transmission, styling and design improvements in the cars of tomorrow.

One immediate possibility is a smaller transmission that will result in a much lower drive shaft "hump" inside the car and correspondingly greater leg room for both front and rear seat occupants. The secret here is that the greater *density* of the new fluids will allow the design of much smaller transmissions. In addition, the new fluids have constant transmission load-carrying ability.

When you have a fluid engineering problem, consider the new synthetic lubricants. Their lubricating ability parallels that of oil. Their density and compatibility with many materials may afford you new engineering opportunities. These amazing new synthetic fluids can affect the future thinking, planning and designing of the automotive industry.

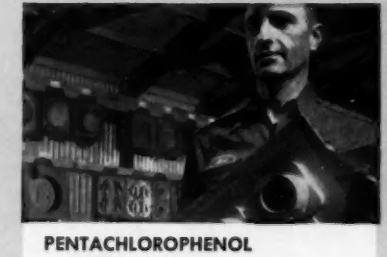
Dow Chemicals Basic to the Automotive Industry

Synthetic Lubricants • Oil and Gas Additives • Antifreeze • Magnesium Calcium Chloride • Polyols • Glycols • Hydraulic Fluids • Paint Removers Lubricants • Caustic Soda • Plastic Molding Materials • Paint and Coating Materials

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW

DOW PRODUCTS *on the automotive front*



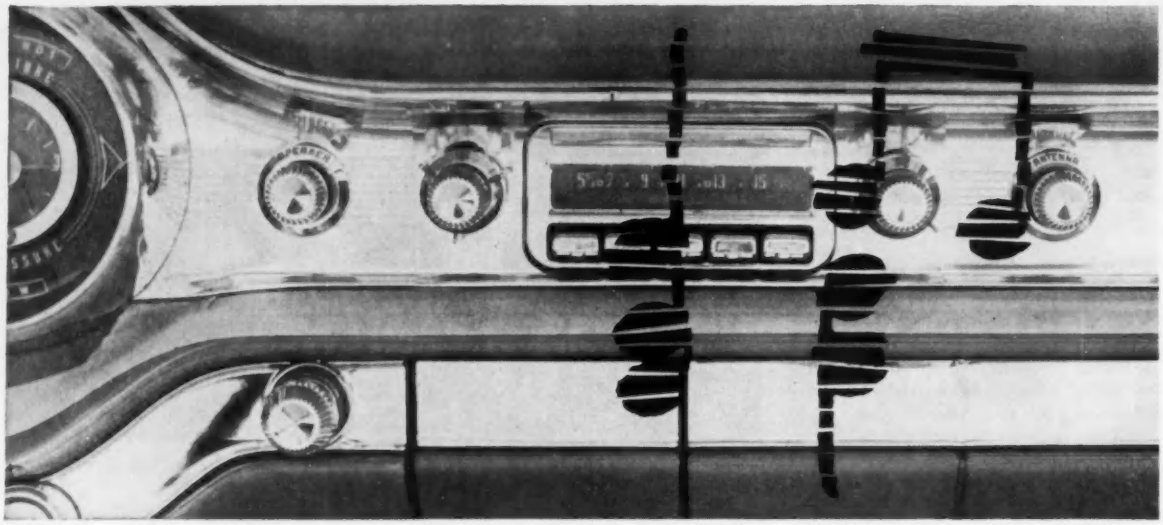
PENTACHLOROPHENOL

Ideally, storage warehousing requires inexpensive but durable buildings. And Penta-treated poles perfectly meet the automotive industry's needs in that direction. Penta helps keep wood "healthy"—free from rot and termites. Dow works closely with wood treaters.

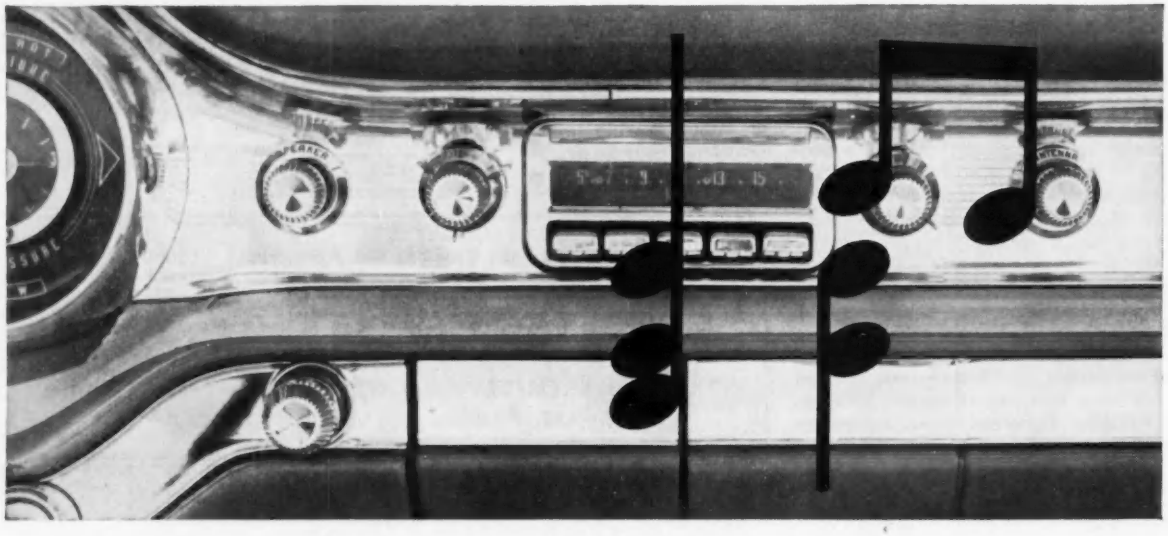
CALCIUM CHLORIDE

Keeping ground test roads dust-free and test tracks ice-free are two of the many automotive uses for Dowflake® and Peladow®, hard-working Dow calcium chloride products. Both these products are easy to handle—and are unmatched for all-around efficiency.

AUTOMOTIVE CHEMICALS LABORATORY. At Dow's Automotive Chemicals Development Laboratories in Midland, Michigan and Freeport, Texas, the test tube replaces the test track as the proving ground of new automotive chemicals — antifreeze, hydraulic and brake fluids, lubricants and additives.



INTERFERENCE / *caused by ordinary cable*



ELIMINATED / *with Packard T.V.R.S. cable!*

The annoying interference with radio receivers, created by automotive ignition systems, *was* a real problem. Old attempts to handle it included resistors at the distributor and spark plugs, but they were only a partial answer. Packard Electric engineers developed a special non-metallic conductor designed to distribute suppression evenly throughout the cable. Same sturdy rubber-neoprene insulation, same long life as other Packard cable, *but with better reception for car radios, nearby radio and television sets and 2-way mobile communications systems.* In spite of the benefits enjoyed through the use of T.V.R.S. Ignition Cable, there is no sacrifice of engine performance!

Now, Packard's exclusive T.V.R.S. (Television-Radio-Suppressor) cable is standard equipment on most new cars. The specialized knowledge of Packard engineers who solved that sore problem is at your service to help you design other cost-cutting or service-improving items. Packard Electric maintains offices in Detroit, Chicago, and Oakland, California for your convenience.

Packard *Electric*

Warren, Ohio

GM GENERAL MOTORS

"Live Wire" division of General Motors

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No matter what your valve gear requirements, it will pay you to check with Chicago's Tappet Division. For here you get the benefits of specialized techniques and facilities which, in 25 years of producing tappets and other valve gear, have established long records of trouble-free service . . . verified in over 25 million engines.

Chicago's special staff of tappet engineers can provide complete valve train designs for all types of engines . . . car, truck, tractor, diesel . . . aircraft, outboard, power mower, or industrial.

Their particular skill in development engineering will also prove a valuable addition to your own engineering staff. And the unique manufacturing and precision testing facilities especially developed by Chicago for valve train production provide you assurance of dependability and long life.

Whatever your valve gear problem, just call Chicago's tappet engineers today. You will find it advantageous to contact Chicago *while you are still in the preliminary design stages.*

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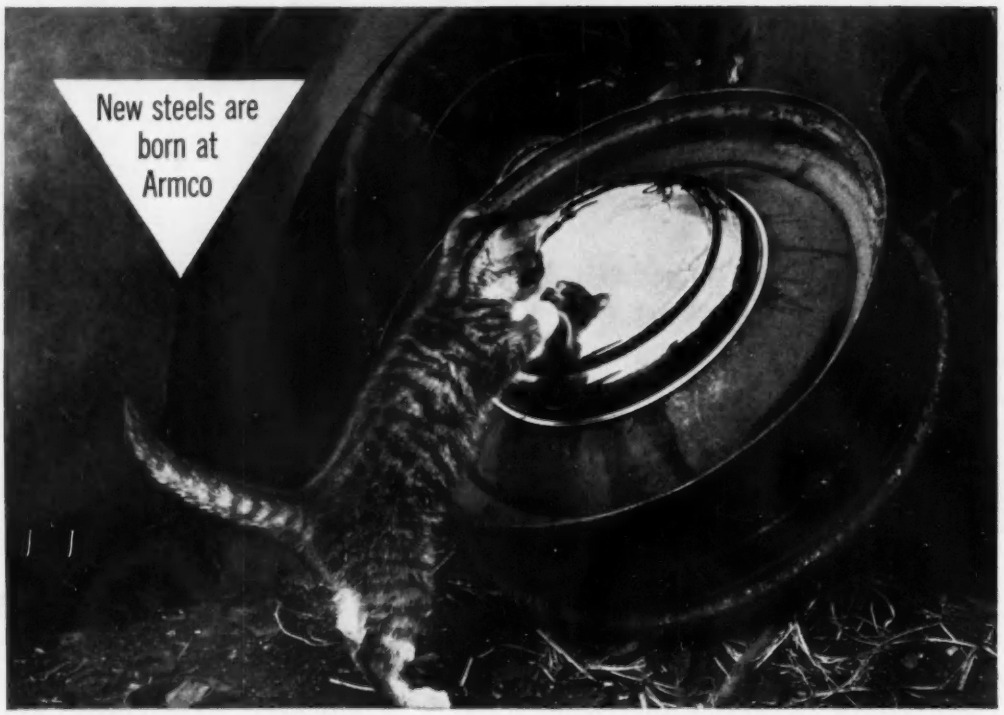

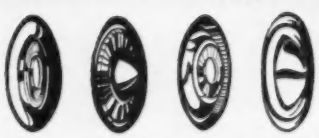

Nine lives? No—but this bright, rust-free hub cap in a field of worn-out autos is shining proof that stainless steel can be depended on to stay new-looking for the life of a car.

For wheel covers and hub caps, no other material can match all these quality advantages of stainless steel:

ENDURING GOOD LOOKS—The pleasing luster of Armco Stainless Steel is *built in*. It lasts and lasts under normal care, without extra precautions, special cleaners, or surface protection of any kind.

EXTRA TOUGHNESS—Solid, dense-grained Armco Stainless resists denting, gouging and scratching from rocks, gravel, curbs, and winter ice—retains its shape under impacts that easily damage softer metals.

LASTING STRENGTH—Because Armco Stainless Steel is exceptionally strong, wheel covers and hub caps need no reinforcement. They stay rigid, too—don't lose their "spring" no matter how often they're taken off and put on.

CORROSION RESISTANCE—Armco Stainless is made to resist rust. That's why it easily withstands effects of rain, snow, and street chemicals. Then too, it is not affected by even the strongest detergents or white wall cleaners used at home or in wash stations.

Service proved

Lifetime service by millions of stainless steel wheel covers and hub caps is the ultimate proof of their superior durability. That's why Armco Stainless Steel in these vital components can help clinch sales. Armco Steel Corporation, 1509 Curtis Street, Middletown, Ohio.

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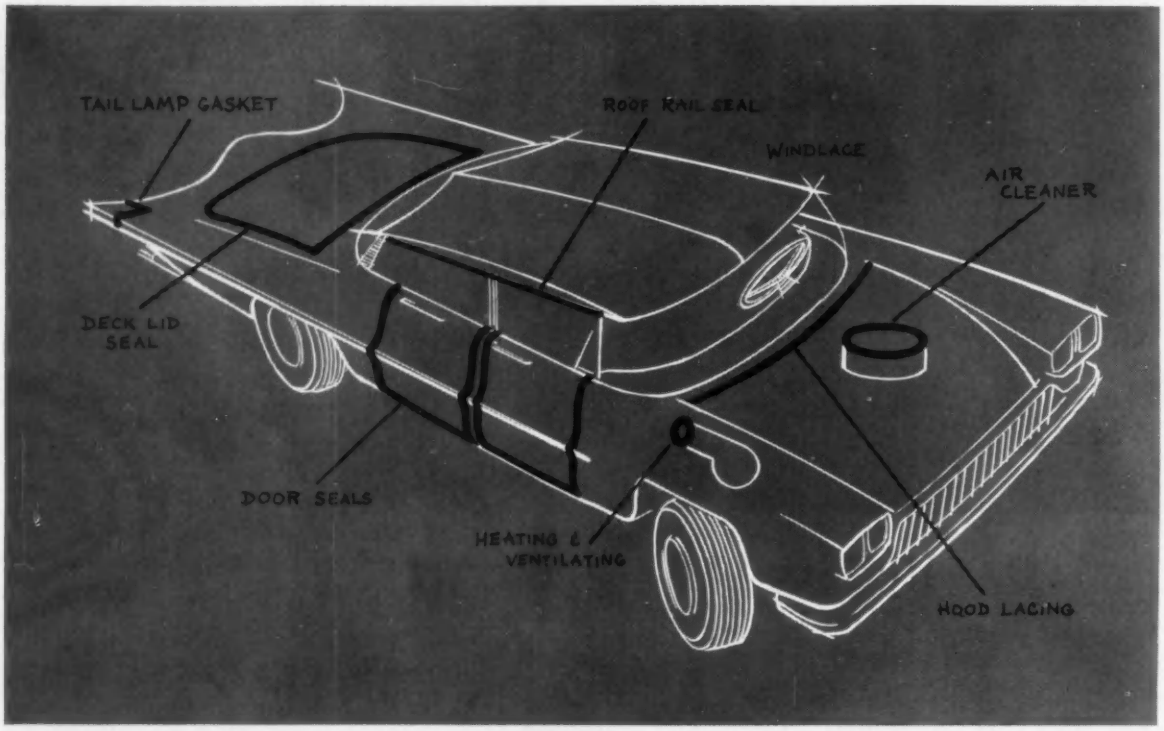
A new and improved body seal: extruded closed cell neoprene

New approaches to body sealing and gasketing are possible with extruded closed cell neoprene. It can be extruded into low-pressure body seals of controlled softness that are weather and ozone resistant, and have low water absorption. The "self-skin" of these extrusions and the closed cell structure beneath removes the need for a protective coating. Tighter radii can be turned without wrinkling, providing an effective seal. For more information write for your copy of EXTRUDED CLOSED CELL NEOPRENE SPONGE. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. SAE-4, Wilmington 98, Delaware.



Applications of extruded closed cell neoprene.

Complex cross sections can be extruded.

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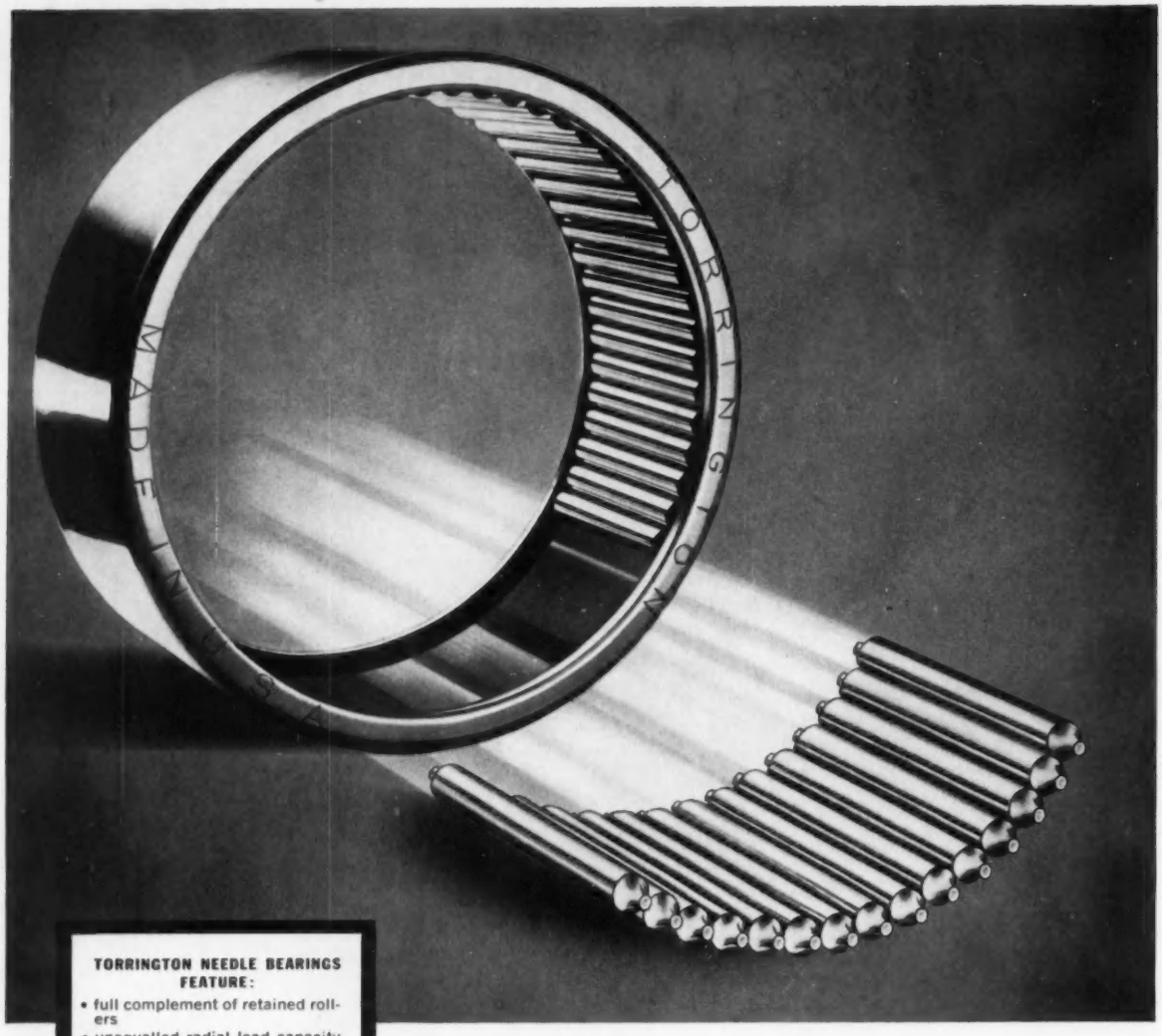

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- runs directly on hardened shafts
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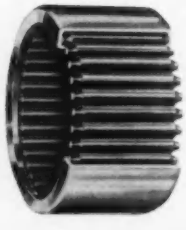

Here's Why Torrington Needle Bearings Provide Maximum Radial Load Capacity

The Torrington Needle Bearing's full complement of small diameter rollers provides the largest possible number of bearing contact lines in the load zone.

This feature gives Needle Bearings a higher radial load capacity than any other bearing of comparable size. Precision rollers ensure smooth anti-friction performance with low coefficient of starting and running friction, to match this unequalled capacity. Rollers are positively retained by the turned-in lips of the outer shell, permitting simple, economical installation and assembly.

Torrington experience spans twenty years in design and application of Needle Bearings to equipment of all types. This experience is at your disposal to help you secure the ultimate in performance built into every Torrington Needle Bearing. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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SAE journal

For Sake of Argument

Thoughts about Thoughts . . .

Some folks get so used to overcoming resistances in their daily business rounds, they lose sight of original objectives. They push so hard as to fall forward on their faces if the resistance is suddenly removed. When achievement is in sight, they lose interest; look for a new resistance to overcome.

To avoid such unconscious loss of objectives requires constant qualitative reappraisal of our projects. It's all too normal to find more happiness in the hunt than in the finding . . . more pleasure in pursuit than in the catch.

The man who stops chasing rainbows soon starts being chased by worries. The man who is done with striving is close to being done to death. But worst of all is to know what you want to do and lack the inner drive to get on with the doing of it. This combination leads fastest to emotional confusion. When the man who used to sit and think gets down to just sittin', mere boredom is his worst menace. When he keeps on thinking, however, but can't get over just sitting, frustration is just around the corner. It's bad enough to keep crossing bridges before you come to them. But it's worse never to come to a new bridge.

Some say there's more fatigue from circumscribing patterns of thought than from too much mental activity. A change of thought can be as restful as cessation of ideas . . . and is much easier to achieve. It's the constant tramping over well-known circular paths that tires most. Changing to new paths occasionally — even when undergrowth has to be slashed to find them — can be refreshing as well as rewarding. The new may even connect up eventually with the old, making them broader and no longer so wearying or circumscribed.

What we do is likely to direct our thinking just as surely as what we think determines what we do.

Norman G. Shidle

FROM NEW YORK: "All four of my brakes are always perfectly adjusted whether I'm on the throughway or driving in bumper-to-bumper traffic in the city."

FROM DENVER: "There's new pleasure in mountain driving now that I know my brakes always have maximum stopping power."

FROM ATLANTA: "Knowing our brakes are never out of adjustment gives me a wonderful safe feeling. I'm at ease even when taking the children to school."

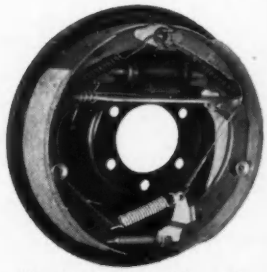
FROM MINNEAPOLIS: "In all kinds of weather, self-adjusting brakes give me stopping power at its best—and save the cost of brake adjustments."

AGAIN . . . BRAKES ARE NEWS IN DEALERS' SHOWROOMS!

Bendix* Self-Adjusting Brakes give dealers a double-barreled sales appeal: safety plus economy. And those in close touch with today's market know that these two appeals —safety and economy—are among the most powerful sales points that can be made to the American buying public.

Car prospects quickly realize that there's real safety in always maintaining the brakes at maximum stopping power. And the obvious savings that they make by eliminating the expense and bother of periodic brake adjustments. What's more, with all brake shoes always correctly adjusted, there's always the right clearance between pedal and floor. And that's a feeling any car buyer appreciates.

Reasons like these make self-adjusting brakes a good "talking piece" for dealers. It won't be long before car buyers everywhere will know about self-adjusting brakes —and want them. But this latest advancement in brakes joins power brakes and power steering as examples of how Bendix pioneers and develops improvements to meet the needs of the automobile industry.



When shoe clearance exceeds a predetermined amount, a ratchet sets up the star wheel adjuster one notch—as the brakes are applied when the car is in reverse. This automatically adjusts the shoes to exactly the right fit within the drum and compensates for lining wear.

*TRADEMARK

Bendix PRODUCTS DIVISION South Bend, IND.

Bendix AVIATION CORPORATION

chips

from SAE meetings, members, and committees

WHERE IS THE TOP to the price of ground support equipment? The present 70% figure for support of an ICBM has followed on the heels of 50% for the B-52 and 20% for a Century series of fighters. These figures do not include indirect support such as buildings, runways, and other permanent installations.

EFFECT OF WEIGHT on car performance is one of the reasons so many manufacturers are looking toward using more aluminum parts, says American Motors' John F. Adamson. A savings of 50 lb in weight can equal a pretty good increase in engine output. Aluminum can be a cheap way to get additional performance . . . especially when it is recognized that an added 10 hp and 15 ft-lb of torque may require an entirely new and bigger transmission, propeller shaft, and axle.

It's good to be willing to admit an error. But it's better to create an improvement while making the correction.

FUEL COSTLIER THAN GOLD . . . The ion engine — the first of a new breed of rocket engines — burns a fuel more costly than gold.

To get to Mars, a 40,000,000-mile trip, it would "burn" about 2200 lb of cesium. Cesium costs $750/lb; gold costs $600/lb.

The ion engine operates by first breaking the cesium atom into positive ions and negative electrons. Then it boosts the ions by means of electrical jolts to high speeds and exhausts them from the tail. The reaction to the exhaust gives a forward thrust.

Cesium was chosen as the fuel for the engine because of its very high weight. The greater the weight of the particles in the ion rocket exhaust, the greater the thrust of the rocket.

IN SOLID STATE STUDIES OF GRAPHITE, methods have been evolved for production of graphite filamentary crystals. These have indicated tensile strengths on the order of 3,000,000 psi . . . which is a 100 to 1 increase over the normal properties of graphite.

MISSILES' POWERPLANTS are made of tungsten, graphite, and special ceramics which resist temperatures of over 4500 F. That's 1750 degrees above the melting point of steel.

100 TIMES THE POWER OF CURRENT ROCKET FUELS — that's what monatomic hydrogen, the ultimate in chemical fuels, is capable of producing. Herbert Broida, who heads free-radical research at the National Bureau of Standards, reports however, that it will be years before it would be practical as a fuel. Even when stored at −451 F, it loses half its energy every day. Monatomic hydrogen is "burned" by allowing it to warm to −424 F. Broida has made 1% concentrations, but he thinks concentrations of at least 10% are needed for practical use in rockets.

A NEW ANODIZING TREATMENT imparts corrosion resistance to magnesium and its alloys but allows tinting or lacquering.

BUREAU OF MINES' scientists have produced the first large casting of molybdenum to shape. It's a hollow cylinder 4½ in. wide and 8 in. long. A 30-lb charge of molybdenum was used for the casting.

Moly's melting point of about 4750 F defeated previous attempts at cast shapes: The crucibles melted before the molybdenum did.

Scientists circumvented this problem by using a high-density electric arc, operated by remote control in an inert atmosphere, to melt the moly in a water-cooled copper-lined pot. The molten metal was then poured through a number of troughs into a rotating graphite cylinder where centrifugal force sent it to the walls for hardening to the cylindrical shape.

It is the seeing, not the seen, that needs changing.

MISSILES cost more per pound than airplanes but 30% fewer manhours of labor are expended per dollar's worth of output, says Douglas Aircraft's President Donald Douglas, Jr.

HIGHER EFFICIENCIES are expected from solar electric batteries based on organic dyes instead of hyper-pure silicon.

HOW TO

Choose A VTOL Powerplant

Based on paper by **C. T. Hewson,**
Rolls-Royce, Ltd.

At each extreme of the VTOL speed range, choice of a powerplant almost fixes itself.

• A very low-speed jet supported aircraft demands a very low-speed jet fan (as in a helicopter).

• A high-speed aircraft (around Mach 3) requires so much thrust that the propulsion powerplant is also used for take-off. The powerplant can be the same whether the engine jets, the engine pods, or the whole aircraft are turned through 90 deg.

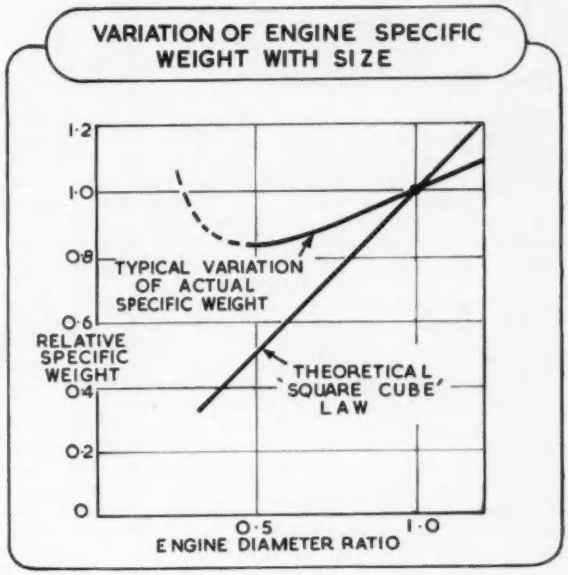
Between the extremes, the choice is influenced by the speed range desired, and whether military or civil use is envisioned. There are many considerations in making each selection.

In military aircraft, for instance, engine noise is a comparatively unimportant consideration. The small pure jet engine scores heavily because of its low weight, small size, and low momentum drag. Toward the lower speeds, a high jet velocity fan might be used to reduce the weight even further — with some penalty in powerplant size. In the next to the lowest speed range, the low jet velocity, fully tilting powerplants come into their own, especially if ground effects and extended hovering are important considerations.

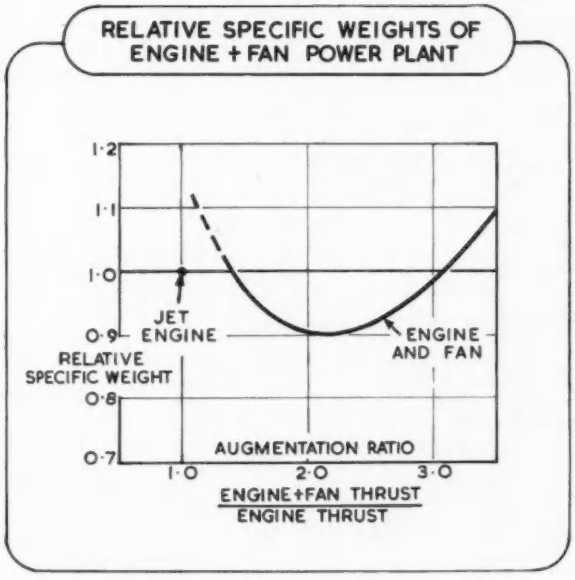
For civil VTOL, on the other hand, a low noise level is the overriding consideration. So, low jet velocity powerplants are necessary. The low-speed fan suits lower speed civil aircraft, because of its low noise level, fuel economy and small ground effects.

For high-speed civil aircraft, low jet velocity fully tilting powerplants are unsuitable for cruise, and low jet velocity fixed fans bring a correspondingly low transition speed limit. What is needed is a powerplant whose main engines are designed for cruise and are augmented by fans for vertical take-off. The fans may be designed for low-altitude, low-speed cases only; the fan jet velocity may be chosen to give the highest acceptable noise level. A device, such as a jet flap, can be used to reduce transition speed while maintaining high wing loadings for cruise.

Powerplant weight and fuel consumption considerations



Actual variation in engine specific weight with size does not follow the theoretical square-cube law, because the metal thicknesses and engine accessories do not scale down accordingly. Although the square-cube law states that the specific weight varies as the diameter, the specific weight can start to increase after a certain point as an engine is scaled down. The minimum diameter for a straight jet engine is 12–18 in.



If a turbofan is used to decrease jet velocity, increasing the bypass ratio will result in a minimum specific weight below that of the pure jet engine. If lift powerplant weight were the only requirement to be considered, a number of small, fairly high velocity fans would be the right choice.

The combined weight of powerplant plus fuel used for take-off and landing is a very important factor. Since fuel consumption reduces with increasing augmentation ratio, the optimum point is moved toward the higher augmentation ratios. If the aircraft is intended for extended periods of hovering, a lower jet velocity powerplant is used, even at the expense of powerplant weight.

(continued on next page)

How to choose a VTOL power plant

. . . continued

Emergency power

Reserve power requirements for civil VTOL are much greater than for military VTOL.

For small military aircraft, range or payload can be reduced for a hot-day, high-altitude take-off. In the case of engine failure, the important consideration is only to prevent the aircraft from rolling over on its back so that the pilot can be ejected safely. The excess of thrust over weight at standard sea level conditions can then be about 5–10%.

For civil aircraft, sufficient power reserves must be available to enable the aircraft to take-off with a reasonable payload under adverse conditions. An augmented engine has an advantage because the fan can be overspeeded without greatly altering the engine speed, thus providing higher emergency thrust than available from a pure jet engine. A highly rated pure jet engine will have only about 5% thrust in hand above its design maximum figure before the turbine blades fail, whereas a fan engine could give appreciably more at a moderate increase in weight and jet noise. Actual percentage excess of thrust over weight required depends on the aircraft configuration and number of lifting engines.

Aircraft control

Up to forward speeds at which the normal control surfaces supply sufficient control moment, the aircraft must be stabilized by some other means.

Air jets at the aircraft extremities are used when the engines are grouped closely about the aircraft center of gravity. Differential engine thrust — more convenient and less heavy — is used where the engines are widely spaced about the center of gravity.

In the first case, the response to a pilot's signal depends on the rate of altering the air jet nozzle areas, and can be done extremely fast. The air jets are fed by a fixed percentage of engine air bled from the engine compressor delivery.

A small size engine is most suitable when control is obtained by varying the thrust of opposite engines, since engine response rate increases with reducing size.

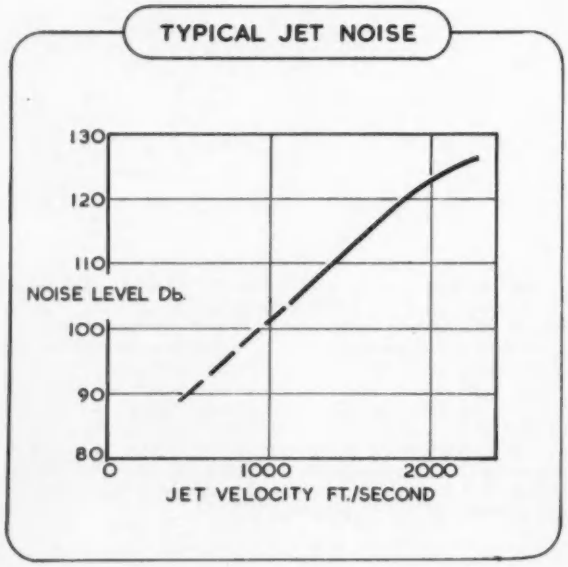
Height control during the hovering or transition phase is done by variation of the lifting thrust, so the small engine is best.

Ground effects

A lift powerplant with a cool, low-velocity jet will be least harmful in regard to ground effects, despite the greater mass flow. On the other hand, the effects of hot, high-velocity jets can be drastic, and these engines will require a special grid or platform from which to take-off.

The landing problem is eased because the hot jet impinges on the ground surface for a shorter time. In an emergency, the aircraft can be landed almost anywhere.

Recirculation is more severe with hot jets, and the take-off grid or platform should be designed to prevent the diluted exhaust gases from getting into the engine inlet and causing a rise in intake temperature.



Powerplant noise

Where low noise level is important, the choice tends toward a number of low velocity jet engines. The noise of a jet is dependent on the area of the jet and on the eighth power of the jet velocity.

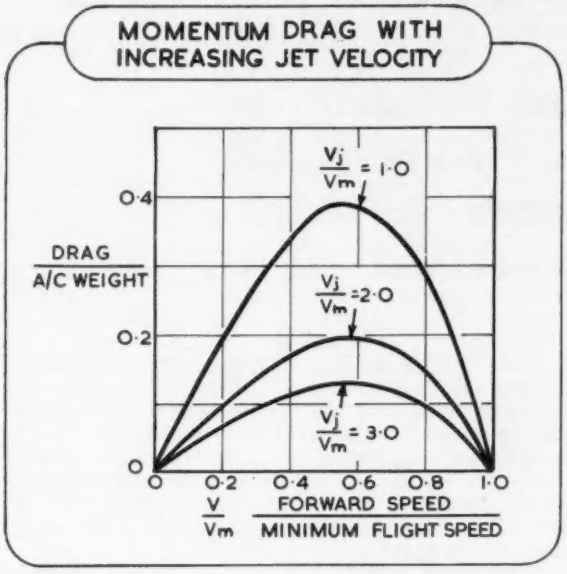
Low blade tip speed is also necessary since there is a noise contribution from the pressure field set up by the blades.

The illustration shows how the noise of a typical jet engine, measured a few hundred feet from the nozzle, reduces as the engine is throttled back.

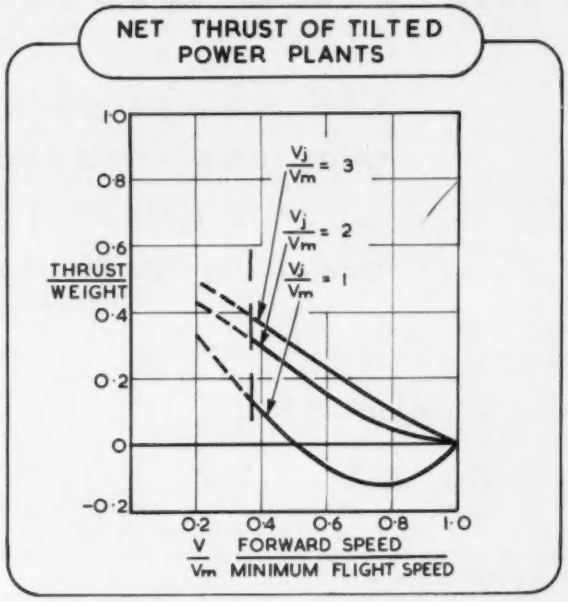
To Order Paper No. 64R . . .
. . . on which this article is based, turn to page 6.

Powerplant size and drag

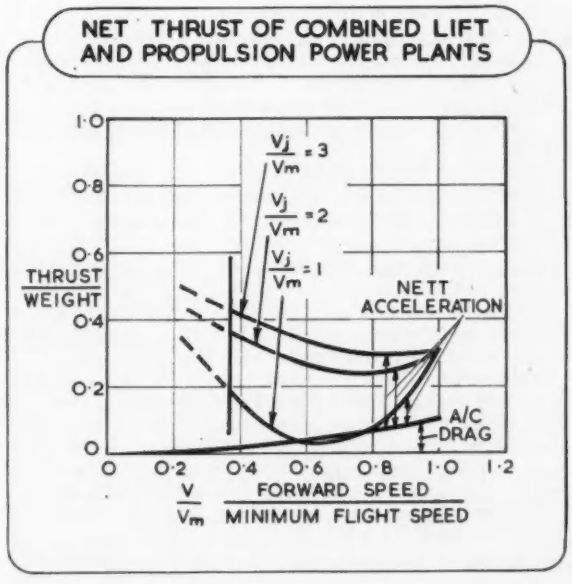
Momentum drag of the lift powerplants can be reduced by increasing the jet velocity (V_j), thus lowering the greatest drag on a jet-borne aircraft during acceleration.



An example of this is a fixed lift powerplant in an aircraft which accelerates so that the wing lift just supports the aircraft weight at flight speed V_m. During acceleration, the lifting power units may be throttled back or multiple units shut down progressively, so that the wing lift plus lift thrust equals the aircraft weight. The smaller drag humps at higher jet velocities are shown for the case of reducing the number of multiple units.



Doubling a jet velocity can turn a drag of 13% of the aircraft weight into a net thrust. By deflecting or tilting the lift thrust to provide a horizontal component, we have a net thrust over most of the speed range, with the exception of the higher speed part of the $V_j/V_m = 1$ curve. The effect of deflecting the jet rearwards at a 30-deg angle — the maximum practical angle for fixed powerplants — is shown.



Lift thrust reduces rapidly toward transition speed, and the surplus power can be used as propulsive thrust. Thus we could have a combined powerplant which will give sufficient lift at take-off and sufficient horizontal cruise thrust when the aircraft is wing-borne.

The net thrust of combined lift and propulsion powerplants is shown (assuming the lifting jets are tilted at 30 deg and cruise thrust required at ground level static rating equals one-third of the aircraft weight). The aircraft acceleration is given by the difference of the percentage thrust and aircraft drag. In practice, the lift thrust must exceed the weight to give adequate control of the aircraft height, so the available horizontal acceleration is somewhat greater. In the case shown, the jet velocity must be at least twice the minimum flight speed in order to overcome momentum drag.

If, instead of assuming vertical powerplants with zero efficiency intake, the intake is assumed to be 100% efficient (forward-facing), then the thrust curves change appreciably only at low jet velocities. At these low values of V_j/V_m, we come to the fully tilting powerplant, where the powerplant is approaching a forward-facing attitude at large angles of tilt.

AIR ACCIDENT "Whatdunnits"

CAB investigators—helped by industry and pilot teams—find aircrash causes regularly . . . . and turn their reports into tools for evaluating design progress as well.

Based on paper by

M. V. Clarke and I. H. Hoover

Bureau of Safety, Civil Aeronautics Board

ACCIDENT investigation is a powerful tool for evaluating aircraft design progress. Of particular significance are the on-the-spot investigations and the not unusual subsequent laboratory tests of parts and components which often involve mockups.

The wreckage distribution chart, for example, is a first step in an on-the-spot investigation. On this chart are plotted the exact positions of as many as possible of the identifiable sections, components, and parts of the wrecked aircraft. This plot may:

- Give clues to the exact order of breakup (if there has been lengthy ground slide).
- Show ground impact marks, as well as trees and other objects cleared just prior to point of initial ground contact.
- Help establish the aircraft's angle and attitude at time of ground contact . . . from examination of the relative location of gouges and impact marks.

By these on-the-spot analyses, Civil Aeronautics Board investigators draw from each part and each surrounding circumstance its own particular contribution to the story of what happened. Torn edges of structures are examined for plastic yielding and paint cracking — or other evidence that might identify a "single overload type failure." To separate inflight from ground impact damage — and to analyze the sequence of breakup, the direction in which mating pieces or sections break off is determined. . . . Seeking to know the position of flaps, landing gears, etc., at time of breakup, they examine all hydraulic cylinders and mechanical actuators to determine *their* position at breakup time. . . . Heaters, air conditioners, fire extinguishing systems, and other possible sources of toxic gases are examined for evidence of malfunction. . . . The list is almost endless — and exactingly thorough.

A special group of investigators, for example, checks all possible malfunctioning or failures of fuel, oil, and powerplant controls. The propeller-blade angle, they find, is one of the most important checks to make, because it is indicative of the power being developed by the engine at the time of impact. Usually they can determine blade angles at impact within an accuracy of ± 2 deg . . . from a study of impact marks on blade shim plates, gears, or any part of the blade assembly that can be related to a non-moving part.

Study of the propeller speed control usually gives the speed of the engine at impact. Given the blade angle, speed of aircraft, and propeller governor setting, the engine's manufacturer can furnish a fairly reliable figure for the power being developed. (The speed of the aircraft can easily be calculated by applying the engine-propeller gear ratio to the governor-setting to get the propeller rpm . . . and then multiplying the distance between the propeller slashes in the ground by the number of blades by the rpm.)

Other items checked by a CAB powerplant group include: all engine oil screens for free metal; spark plugs; and interiors of combustion chambers.

As a matter of course, samples of fuel are obtained when possible for later analysis. . . . And, where possible, all powerplants are finally removed to a shop for more extensive disassembly and analysis.

The value of mockups in analyzing engine-accident relationships was especially well illustrated in investigation of a recent Convair 240 accident. This aircraft crashed a few hundred feet short of the runway. The wing burned off, and all aboard were killed.

Investigation disclosed the initiating cause to be the fatigue of a cylinder flange. This released combustibles which were ignited by the exhaust.

Ordinarily, such a fire is contained by the fire seals and extinguished. But here, the fire seals were ineffective. The fire progressed rapidly into the wheel well and melted the main fuel line in that area, releasing fuel in large quantities. The valve that could have stopped this flow of fuel was found open. The entire path of the fire rearward into the primary wing structure was revealed when all of the pieces were assembled on a mockup frame.

Tougher than TV "Whodunnits"

Incidentally, this investigation resulted in a change in the cylinder handling procedures of the particular operator, a modification to the fire seals, and a change in the crew fire control procedures. This accident illustrates that seldom is the cause of an accident one pat thing, but more often a series of events all adversely cumulative.

A mockup of specfiic structural sections of the wrecked aircraft is also effective in finding an accident cause. Often it helps to demonstrate beyond a doubt that a specific occurrence did, in fact, happen. This is particularly true in the area of inflight fires, mid-air collisions, and explosions. Either partial or complete reconstruction is a slow and tedious process, however, and is undertaken only when (a) the preliminary work has not disclosed the cause of the accident and (b) the structure is still suspected of being the cause.

Difficult and Hazardous Investigations

Some investigations are hazardous as well as difficult for the investigators. The much-publicized United Airlines-TWA collision over Grand Canyon in 1956 was one of these.

Both aircraft sustained extensive damage during this inflight collision. Each broke into countless small pieces as it struck the rock walls of the canyon. Fire after impact destroyed a considerable portion of each. The remote and relatively inaccessible location of the two wreckage sites presented unusual practical and technical problems.

But CAB's structural group investigators — with U. S. Army help — found ways to bring from the canyon sufficient evidence to:

(a) Establish conclusively that a collision had occurred, and
(b) Determine the relative altitude of each of the craft at the instant of impact.

The key wreckage pieces that survived the ground fire which occurred following the impact were:

1. A large section of the DC-7 left outer wing panel.
2. Several pieces of DC-7 left wing structure.
3. Several sections of the lower L-1049 fuselage containing propeller cut marks.
4. Several pieces of the L-1049 empennage structure.

Two independent methods were used to establish the convergence angle between the two aircraft at impact in this Grand Canyon case . . . and both gave substantially the same convergence angle.

The first method: Scrape marks on one aircraft were related with scrape marks on the other to complete a relative velocity vector diagram. No assumptions had to be made. The derived convergence angle at impact was relatively precise.

The second method: The angularity of the propeller cuts and the spacing between them was used to arrive at the convergence angle. The cutting propeller tip helix path was determined, using known or assumed values for rpm and aircraft speed. Then this path was oriented with respect to the cuts to arrive at the convergence angle.

Inflight Explosions

Need to consider inflight explosions as one of the numerous possibilities among accident causes has challenged investigation techniques more than once recently. The Western Airlines CV-240 which exploded near Daggett, Calif., in 1957 is a case in point. Here, little of the fuselage area was damaged in a manner characteristic of a high-velocity explosion. An explosion of relatively small energy was, therefore, indicated.

Recovery, reconstruction, and study of bits and pieces from the hole in the sidewall of the fuselage lavatory area pinpointed the origin of the explosion. It was directly on top of the wash-basin shelf at about Fuselage Station No. 658.

Laboratory analysis showed that grayish and dark deposits on specimens from the lavatory area were characteristic of an incomplete detonation of dynamite. A fragment of copper found in the cabin insulation — similar in composition to the shell of an unexploded fuse-type blasting cap found in the toilet — pointed to detonation of the dynamite by application of heat to a blasting cap. . . . It indicated also that the first attempts to detonate were unsuccessful. The dynamite seems to have been resting on the washbasin shelf while the fire was being applied to the blasting cap.

Increasing Difficulties

The aircraft accident investigator's task becomes increasingly difficult as time goes on. Higher operating speeds and greater design complexity of aircraft mean greater disintegration and greater amounts of more complicated components to check up on when accidents do occur.

Right now, the CAB is re-evaluating its investigative methods, looking toward changes necessary to cope with jet transport accident investigation. Airborne flight recorders — required on the newer jet aircraft — are expected to be of invaluable assistance in future accident investigation.

Also, CAB is working closely with manufacturers and airlines toward new ways to insure that accident evidence is preserved and expeditiously examined after any accident involving a jet transport.

To Order Paper No. 20R . . .
. . . on which this article is based, turn to page 6.

Design Features of European Trucks

Based on paper by

John Alden

Vauxhall Motors, Ltd.

ENGINEERING changes in European trucks reflect continuing effort to achieve economies in operation. Thus, for example, we find diesel engines becoming ever more used for all types and sizes of vehicles down to the small, the 16-in. tire becoming more popular, and steel cord tires supplanting the conventional fabric construction.

By the same token, many features common to American trucks have failed to win acceptance overseas, as for example, hypoid gears, fluid couplings or torque converters, and tubeless tires.

basic vehicle layout

A very important trend has developed to improve vision from the cab of the normal or conventional control type of vehicle. Engines are being placed lower in the frame, hood and wing lines are being dropped radically and this, together with a very deep, curved, one-piece screen has, in some instances, halved the ground area in front of the truck which the driver cannot see (Fig. 1). In one recent model, the hood line was dropped by some 6 in., and the bottom of the windshield by some 5 in. Bedford and the German Ford example this trend.

In America the trend appears to be toward raising the hoodline to produce a massive front and appear-

Why European Trucks Differ from Ours

THE geographical and topographical characteristics of Europe, being unlike those of the U.S.A., influence the design of foreign trucks in directions often markedly different from those in America. Many countries do not have good road systems, and while secondary roads are well surfaced, they are narrow and limit speed. Long distance hauling is still dominated by the railroads, leaving to motor vehicles the short-haul, congested area haulage.

Great Britain had, in 1956, the greatest concentration of motor vehicles per mile of road of any country in the world. Had every vehicle been put on every available road at one time, there would have been one vehicle for every 196 ft. America ranked second at that time, while West Germany ran a close third.

There are, of course, other factors influencing design. Outstanding is the cost of fuel. Gasoline costs 59.8¢ per Imperial gal while diesel fuel sells for 60¢. Obviously, this places emphasis on economy.

But granting all the differences, there are engineering design developments of interest and significance to the American automotive engineer. They are discussed in this article.

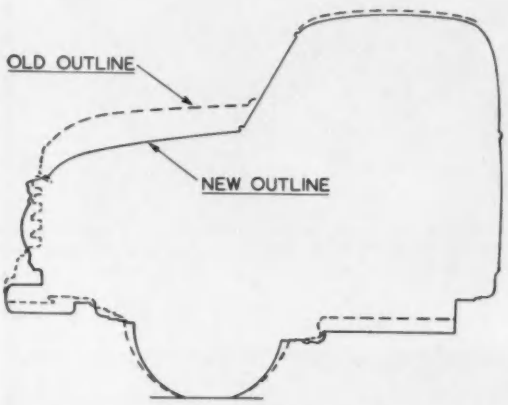


Fig. 1 — Trend among European producers is to improve driving vison by placing engine lower in frame and dropping hood and wing lines radically.

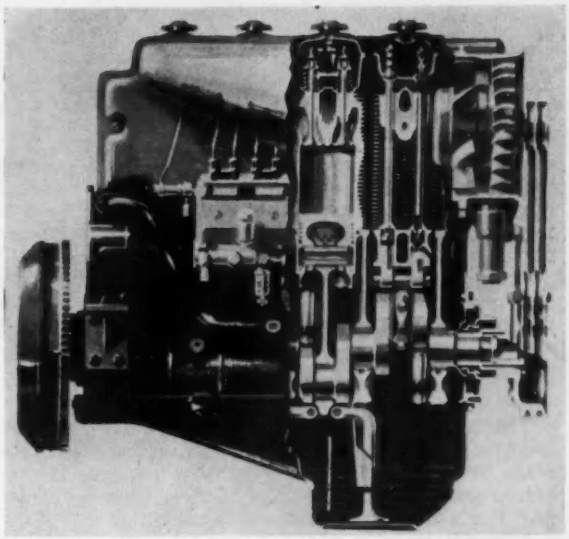


Fig. 2 — German Deutz aircooled diesel represents a design trend. Diesels down to 100 cu in. capacity have become commonplace in Europe.

ance. This seems basically wrong, as the primary objective in styling a commercial vehicle should be function and safety. If stylists cannot produce a vehicle with attractive appearance when these two objectives have been satisfied, they are falling down on the job.

Probably the most modern trend is toward the cab-forward-of-engine type, prompted by the desire to overcome the need to clamber over the front wheel to enter the cab, typical of existing COE types. In many instances the engine is still mounted so that it literally bisects the cab, but in some instances the engine is mounted under the seat or to the rear of the cab and a straight-through, three-man cab layout is provided.

CFE design is used in most cases for the under 6000-lb gvw light van and pickup, which account for more than 50% of the market. Typical examples are the B.M.C., Fiat, and German Ford FK1000, which have the engine mounted under the driving compartment, and the Volkswagon, which has it at the rear.

engine types

Over 20,000 lb gvw, the diesel is rapidly becoming universal in its use, but it is being continually developed for practically all vehicle types and sizes and it is now freely available down to 100 cu in. capacity or less. These engines are invariably 4-cyl, direct-injection types giving higher specific fuel economy.

The additional cost of a 23,000-lb gvw diesel engine vehicle in Great Britain can be saved after approximately 15,200 miles, due to the 50% advantage in economy over the gasoline engine, the cost of the two fuels being approximately the same. Other advantages of the diesel are: a flatter and wider torque curve, providing better lugging characteristics (torque is more important than horse-

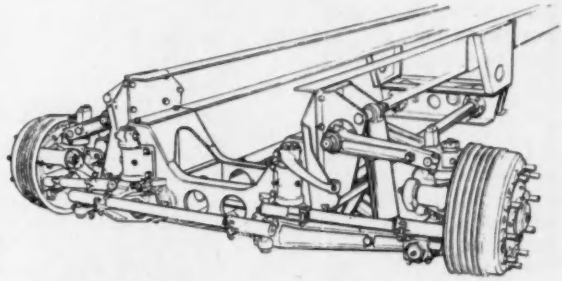


Fig. 3 — Independent suspensions are found mostly on buses, as exampled by this torsion bar independent front suspension used by Leyland. Leaf springs still predominate on trucks of 6000 lb gvw and over.

Fig. 4 — Cutaway view of B. M. C. Gypsy, 4-wheel-drive jeep, rear suspension trailing arm, showing rubber used in torsion.

Design Features of European Trucks

. . . continued

power generally), better braking assistance, longer life (this advantage is waning), and better economy in congested areas where speeds average 8–10 mph. This last advantage stems from the diesel's superior economy at part-throttle openings.

One of the most interesting engine design trends in Europe has been the development of the aircooled diesel, such as the German Deutz shown in Fig. 2.

frames

There is considerable interest in the use of welded frames, but for the heavier and more expensive class of vehicle. Most manufacturers use riveted construction, usually of the "cold-squeeze" variety, and the use of fitted bolts is decreasing.

Integral body and chassis construction is being used on many of the below 6000-lb gvw class vehicles, but this construction closely limits the number of vehicle types that can be obtained from one basic design. For this reason many manufacturers keep to the conventional chassis frame in order to provide a chassis cowl or chassis cab option which can be fitted with special bodywork.

suspension

Leaf spring suspension for vehicles of 6000 lb gvw and upward is practically universal and seems destined to continue for many years. Independent suspension is used mostly on buses, an example of which is the Leyland (Fig. 3). Where independent suspension has been introduced on trucks it has always been at a weight or cost penalty, nevertheless manufacturers are fully aware of the need to improve both laden and unladen ride. Lower spring rates are being introduced gradually and shock absorbers are now usually standard on front axles and optional on rear.

Considerable attention is being given to reduction of unsprung weight and here the smaller 16-in. diameter wheels and tires help — upwards of 100 lb per vehicle can be saved in this way. New interest is being shown in coil and rubber spring development. In some instances, leaf and coil spring combinations are used. The Fiat rear suspension is an example. Rubber springs used in torsion are to be found on the B.M.C. Gypsy 4-wheel-drive jeep (Fig. 4) and rubber sandwiches are used on the Midland Red bus.

Some leaf spring mountings are particularly interesting. The German LLoyd, for example, uses bonded rubber between the spring and the frame and rubber pads between leaves (Fig. 5). In the M.A.N. spring layout the main leaf effective length decreases with deflection and is practically free from the usual thrust and braking torque eye stresses.

Air suspension is gaining ground in some countries and losing it in others. Generally speaking it is used only on tractor-trailers and buses. The inherent cost increase is one reason for its lack of popularity, but other factors are continuous riding on the bump stops where very big overloads are used constantly, and the poor performance of some leveling valve systems. Air ride gives the truck engineer his first chance to provide constant riding height and constant ride frequency, both in laden and unladen condition, and for that reason it must have an important part to play in the future, but much development work lies ahead. The Guy (shown in Fig. 6) illustrates one recent air ride scheme coupled with independent front suspension.

Coil spring or torsion bar I.F.S. is used in the majority of the under 6000-lb gvw vehicles, especially where equivalent passenger-car components are available.

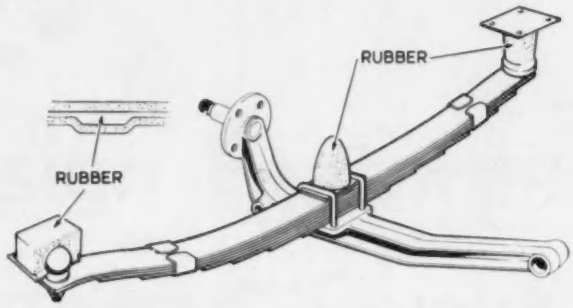


Fig. 5 — German Lloyd truck has leaf springs for front suspension with bonded rubber between spring and frame. Inset shows rubber pads inserted between leaves.

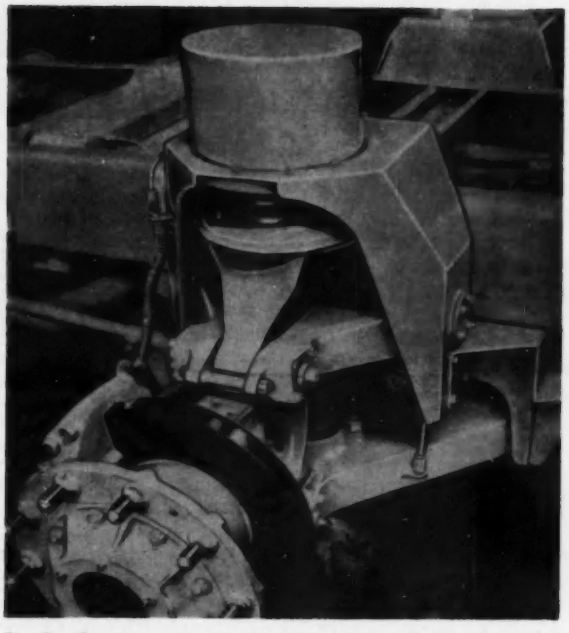


Fig. 6 — Guy bus couples air ride with independent front suspension. A single convolution bellows is mounted over the kingpin on top of the front suspension upper arm. Total wheel deflection of 6 in. results in track change of only ⅜ in. and camber angle change of ¾ in. Spring frequencies are 70 cpm front and 85 cpm rear.

Square Blank Disc Wheel

Inside the Wheel

Detail of Weld

Wheel Disc from a "Square Blank" after Forming

Fig. 7 — Road wheel with disc formed from a square blank results in considerable weight and cost saving.

The Scammell super constructor in the 168,000-lb gvw class employs a rocking front axle, which eliminates frame distortion and gives even wheel loading and a good ride with low periodicity. The axle is suspended from a centrally pivoted beam, road shocks being absorbed by coil springs and built-in dampers. It is located sideways by a Panhard Rod and the fore-and-aft location is by torque arms, ball mounted to the chassis.

wheels and tires

There is a definite trend toward the use of smaller tire diameters, the primary objective being the reduction of cab step and cab and truck body floor heights. It has become increasingly important to lower the excessive height of the driver's seat from the ground, especially on short delivery work where the driver may enter and leave his cab some 200 times a day. Moreover, while mechanical loading minimizes trouble from high body platforms, partial lot unloading can be a time and energy consuming business.

Tires of 15-, 16-, and 17-in. size are being used but the 16 in. is the most popular. Mercedes Benz and B.M.C. have been using 16-in. tires on vehicles up to 2-ton payload (7000 lb gvw), but the trend has been hastened by the introduction last fall of the Bedford (England) 4-ton conventional control vehicle (pay-

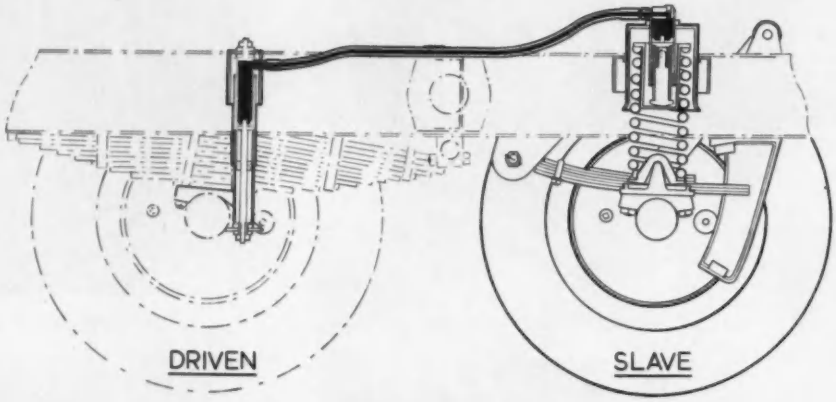


Fig. 8 — Tandem axles with the rear axle trailing are growing in popularity. In this Primrose tandem axle with hydraulic load compensation, the full tractive effort is maintained on the driven axle when unladen. As the payload is increased, the individual axle loads are automatically controlled until, at full load, 55% of the imposed load is taken on the driven axle and 45% on the slave.

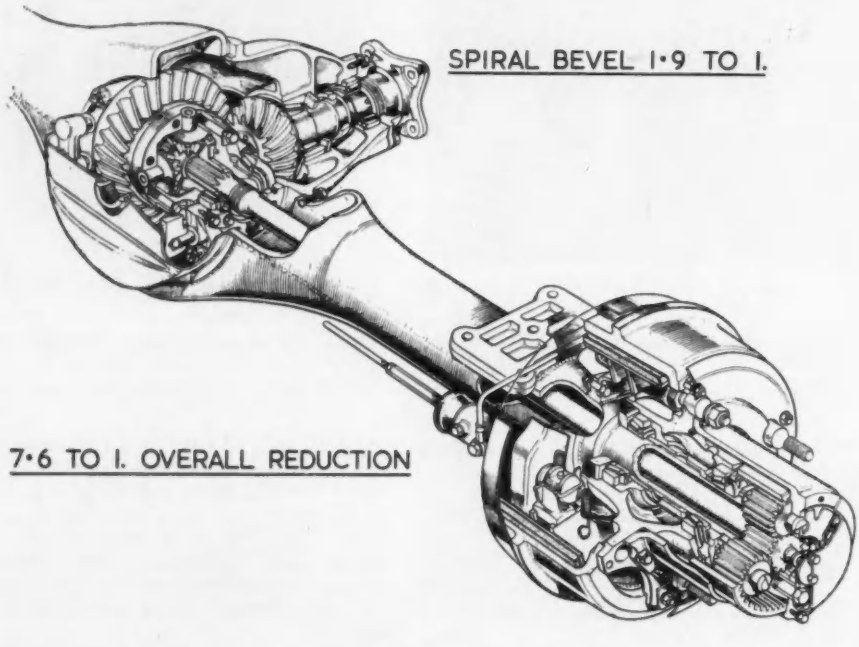


Fig. 9 — Second stage in the Albion double-reduction axle is achieved through planetary gears in the hubs. This examples the trend to put the final gear reduction as near to the road wheels as possible.

load about 9000 lb, gvw 15,000 lb) on 7.50 × 16 size tires. This move reduced body loading height by some 7 in., cab step height by 4 in., and there are the following added advantages:

1. Smaller turning circles, much sought for operation in congested European cities.
2. The use of 16-in. tires provides, in effect, an in-built gear reduction, and in principle, as compared with a 20-in. tire, the load on the axle gears and torque in the axle shaft can then be reduced by around 15% to maintain the same tractive rim pull.
3. While decreased tread life might be expected, due to the higher revolutions per mile, actual experience has shown a cost per ton-mile saving of up to 30% with the 16-in. tire in comparison with the 20-in. The reason is not clear. It may be due in part to the lower unsprung weight, and it may be that the 16-in. tire is more modern in construction.

A second trend of importance is the development of steel cord tire construction. Steel cord tires, such as the Michelin X type, have been found to wear better by 60–110%, maximum improvement being had on straight-run routes without sharp curves. British retail cost for steel cord tires of 8.25 × 20 size is about 91 as compared with 95 for a similar size conventional construction rayon tire of 14 plies. Steel cord tires have a higher load rating but this margin is being whittled down by the conventional tire in the larger sizes.

There is practically no interest in or use of the tubeless tire in Europe. Truck operators do not take easily to the new size classifications and they are suspicious of the overload capacity.

An interesting development in truck wheels in recent years is the evolution of the square blank welded on discs shown in Fig. 7. These wheels give a substantial cost and weight saving over the round blank riveted construction.

front and rear axles

There is a growing use of tandem rear axles where the front axle of the tandem alone is driven. The slave rear axle is mounted so that it carries around 45% of the total tandem imposed weight. In many cases, the slave is lifted clear of the ground by some driver controlled mechanical linkage, and this is usually operated when running unladen to provide maximum adhesion on the driven axle, and no wear or scuffing on the slave. Some linkages give automatic load adjustment between the driven and slave axles so that approximately 95% of the total imposed load is taken on the driven axle with the vehicle empty, and 55% in the laden condition (Fig. 8). It is in the unladen condition that loss of drive is mainly apparent. Such an axle arrangement has many attractions. It probably affords the lowest overall cost combination for gvw's up to 40,000 lb, with none of the disadvantages of the semitrailer.

There is also a trend toward the use of double-reduction rear axles and in an effort to provide the final gear reduction as near to the rear wheels as possible, the latest tendency is to use reduction gears in the hubs (Fig. 9). While such a layout is not new, Europe seems to be recognizing its advantages, particularly as existing axle gear sets and axle shafts can be used in axles requiring a higher load rating and larger overall gear reduction. In this way, smaller axle gears, gear housings, and axle shafts can be used and made common — with accompanying tooling advantages — throughout a given range of different axle ratings simply by the incorporation of suitable hub reduction gears.

Now that better tooling and higher production volume have brought down the cost of 2-speed axles, they are growing in popularity. Nevertheless, many operators think this a complicated and expensive way to provide a high maximum speed for the homecoming unladen vehicle, and a very large number of European manufacturers already provide a transmission with some form of overdrive top gear.

Hypoid gears have won no popularity. Power loss inherent with the rubbing action of the gears is offered as one explanation. Many operators, particularly those with small vehicles, think the hypoid axled vehicle is up to a mile per gallon worse in fuel economy than the equivalent spiral bevel axle vehicle. Disliking the need to use special lubricants and having adequate pinion strength in their existing spiral bevel gear sets, manufacturers see no reason to change.

transmissions

To provide a quick and easy change, there has been some tendency to drop the popular first gear ratio of 7/1 down to 6/1 or even 5.5/1, the loss of reduction being regained in axle gearing and, at the same time, an overdrive transmission top gear, making five forward speeds, is often incorporated to maintain maximum speed.

Fluid couplings and torque converters are not liked and little used because of their inherent power loss and therefore higher fuel cost. Hydraulic transmissions, when used, go into heavy vehicles particu-

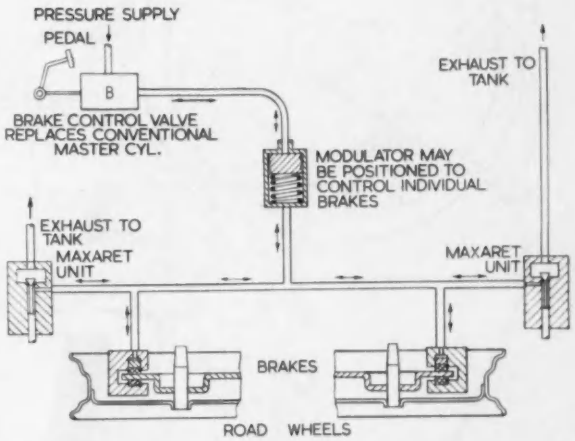


Fig. 10 — Dunlop Maxaret antiskid device. A small flywheel is rotated by each braked wheel; as the road wheel is decelerated so also is the flywheel. A spring is incorporated in the drive between roadwheel and flywheel so that if deceleration is greater than would be experienced during normal braking the spring is deflected and so actuates a small hydraulic valve, which relieves brake line pressure until the deceleration is reduced. The flywheel is then returned by the spring to its normal position relative to the drive. Function of the modulator is to allow an unrestricted flow of brake fluid, allowing brake clearances to be taken up rapidly and, once the brakes are applied, to trim the flow to insure rapid skid connection.

Design Features of European Trucks

... continued

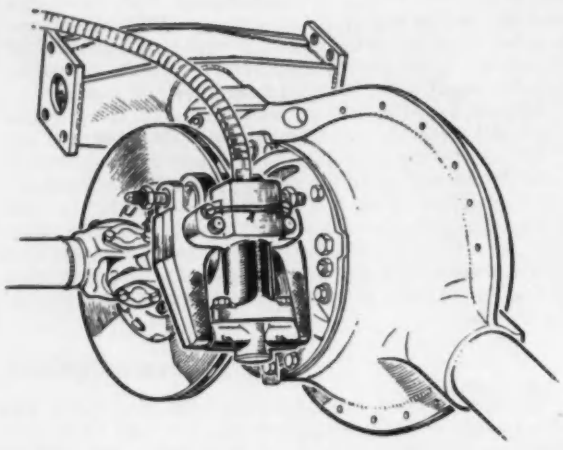


Fig. 11 — Typical European disc brake developed to improve fade characteristics. Such systems treble the number of braking stops which can be made without excessive fade, and brake blocks can be changed in fraction of time required for brake relining.

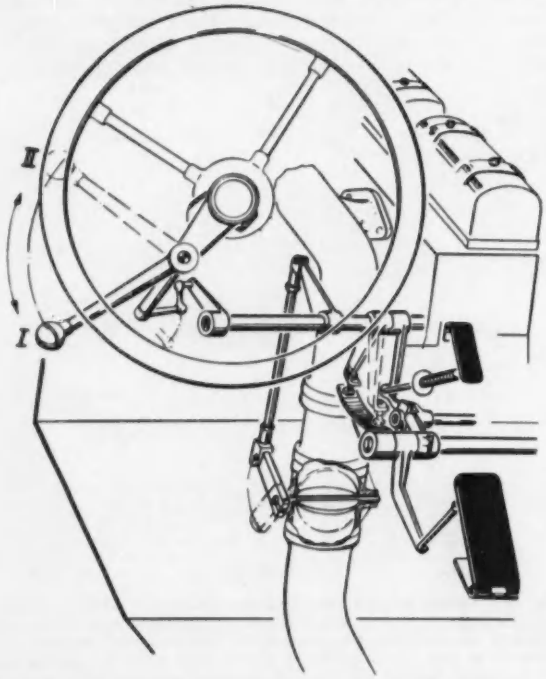


Fig. 12 — Arrangement of a typical European exhaust brake, most popular in Switzerland. The hand lever on steering column cuts engine fuel supply as the exhaust brake is applied.

larly for off-the-road service. The Wilson epicyclic transmission with preselector or automatic, air, or electrically operated control is still widely used, being standard on most London buses, and the GM Hydramatic is manufactured under license by Rolls Royce. The British Hobbs semi-automatic transmission has been developed for various light and heavy vehicles.

Volvo has produced a torsion bar in its transmission drive shaft to give low frequency torsional flexibility to overcome the phenomenon known as transmission rattle. Usually this has been absorbed by some spring-loaded frictional device in the center of the clutch plate.

brakes

Interest in the limitation of wheel locking characteristics is demonstrated by Dunlop's development for vehicle use of the Maxaret antilock system now on the Viscount airliner. The primary objective of this system (shown in Fig. 10) is to back off wheel braking automatically when the tire lock and skid point is reached.

Another recent European patent links the air pressure of an air ride system with air braking so that as load is removed from the vehicle, the air pressure decreases and the degree of air boost is varied automatically as well.

Disc brakes have come to the fore because of the need to improve fade characteristics. A typical European disc brake installation is shown in Fig. 11. Such systems approximately treble the number of braking stops which can be obtained without excessive fade. Brake blocks can be changed in approximately 8 min, in contrast with about 8 hr for the relining of conventional-shoe-type brakes. The hope that disc brakes would result in substantial weight reduction has not materialized.

With smaller diameter wheels and tires have come smaller diameter brakes. This, in actual fact, has provided better brakes from the drum expansion point of view and has indicated that, within certain limits, it is better to go to a smaller diameter drum with a wider shoe than to a larger diameter drum and narrower shoe width.

Considerable interest is being shown in transmission fitted retarders, usually of the electromagnetic type such as fitted by various French producers, so that heavy vehicles may descend long mountain passes without undue use of the wheel brakes. A further point of interest is the use of exhaust brakes, particularly in Switzerland (Fig. 12).

Krupp has designed its diesel engine so that exhaust timing may be varied from the cab by movement of the engine camshaft to provide a built-in brake. While such an arrangement must be costly, it is a forthright and ingenious approach to a very real problem.

Most light-weight European vehicles have both 50% braking ratios and common size brakes front and rear. This arrangement is now being extended to heavier vehicles since with many CFE designs, normal front axle loads plus load transference due to braking gives 50% of total imposed load on the front axles at the tire skid point.

To Order Paper No. 31R ...
... on which this article is based, turn to page 6.

Better Car Cooling Results from New Laboratory Testing Procedures

Based on a paper by

J. D. Loveley and P. W. Wyckoff, Chrysler Corp.

IT IS NOW POSSIBLE to correlate laboratory procedure for hot-room testing of car air-conditioning systems with summer field tests. A reliable laboratory method is of great importance in the development of the automobile air conditioner. If the only method of testing were under actual climatic conditions, it would be impossible to design, develop, and release an automotive air conditioner and still keep pace with model changes and new ideas. With a suitable laboratory method, year round development is possible, and tests under actual climatic conditions are needed only for final approval prior to production release.

Thus, the *U* factor concept has been applied to express the car body heat-transfer characteristics. It is defined as the combined effect of all atmospheric conditions and the properties of the car body involved, which adequately express the heat-transfer characteristics of a car body at equilibrium.

The following equations have been developed to calculate the *U* factor for the car body:

$$H_s = 1.085\ \text{cfm}_i\ (t_1 - t_2) + k + U_b\ (t_1 - t_2) \qquad (1)$$

$$U_b = \frac{H_s}{t_1 - t_2} - \left(1.085\ \text{cfm}_i + \frac{k}{t_1 - t_2}\right) \qquad (2)$$

where:

U_b = Sensible heat transmission coefficient for car body, Btu/hr – F

H_s = Net sensible heat capacity of cooling unit, Btu/hr = 1.085 cfm t_d

t_d = Dry bulb temperature entering – dry bulb temperature leaving cooling unit

cfm_i = Infiltration airflow (corrected to 0.075 lb/ft³)

cfm = Airflow through cooling unit (corrected to 0.075 lb/ft)

t_1 = Ambient temperature, F

t_2 = Average interior car temperature, F

k = Constant representing passenger and instrument sensible heat load, Btu/hr

The *U* factor for a car body includes heat transfer from the car exterior to the interior due to conduction, convection, and solar radiation. Thus, it is not a constant, but will vary with car speed, wind direction and velocity, intensity of direct and diffuse solar radiation, amount of direct and diffuse solar radiation received through glass areas, and the car body properties.

Car body properties affecting the *U* factor are:

1. Size of car.
2. Color of car, which affects the amount of solar radiation absorbed by the body surfaces.
3. Amount and type of glass, because it is highly conductive and transmits a significant amount of solar radiation.
4. Amount of insulation on roof, dash, and underbody.
5. Distribution of conditioned air. For example, if the conditioned air is directed along hot glass surfaces, the *U* factor will increase.

With car body heat transfer well correlated in the laboratory with field tests, the variables affecting unit performance must be considered in order to predict actual temperatures which will be attained in the car body. The factors affecting air-conditioning unit performance are:

1. Dry bulb temperature.
2. Air infiltration. (See Fig. 1 for effect of infiltration on cooling capacity required.)
3. Number of passengers.
4. Type of interior trim and materials used.
5. Car speed.
6. Amount of time car is left standing in sun.

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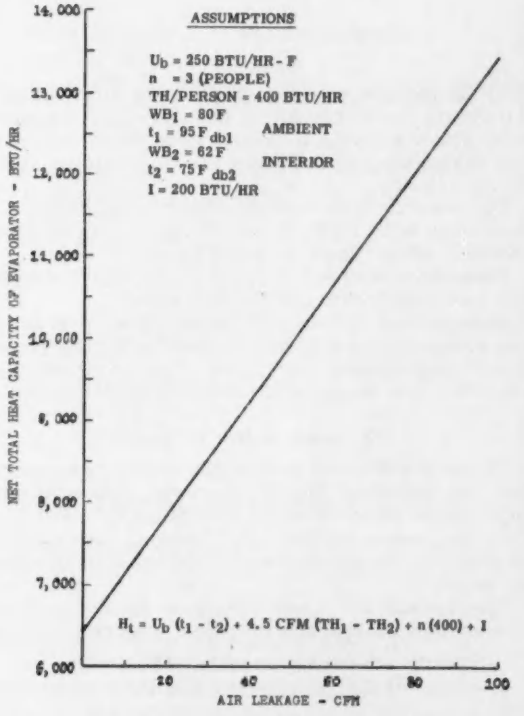


Fig. 1 — Effect of air infiltration on cooling capacity of air-conditioning unit. Because infiltration imposes the additional problem of fresh air latent heat load, the unit must remove both sensible and latent heat.

Piasecki

The Army is getting flying platforms

Three different vehicles to hold up the flying GI are being designed for the Army. The biggest problems are keeping them level and stable.

THREE companies have made three approaches to building aerial platforms or "sky-cars" for future GIs. Each is trying to deliver good performance for this hedgehopping vehicle while maintaining stability and control.

Chrysler designers have picked a two-rotor configuration with rigid, shrouded blades. Control and stability come from a series of vanes.

Piasecki also uses a tandem shrouded rotor design but has cyclic pitch on the rigid rotors.

Aerophysics Division of Curtiss-Wright went to a four-rotor design with no shrouds except for a small guard ring around the rotors. The propellers have drag and flap hinges and collective pitch control.

To Shroud or Not to Shroud

There is a distinct advantage to shrouded propellers for hovering flight. However, this advantage falls off as forward flight speeds go up. First, the drag increases rapidly, and second, the pitching moment of the rotor steadily increases in the nose-up sense.

The reason for these effects is shown in Fig. 1. The shroud around the propeller does three things:

1. Prevents contraction of the slipstream.
2. Stops air spillage around the tip of the propeller.
3. Provides a low pressure area on its lip.

All these work together to give up to a 25% increase in thrust for the same power and rotor diameter. When forward motion is added to the hovering condition, the forward lip of the shroud has a very low static pressure which tends to tilt up the rotor disc. The rotor itself also adds to this effect. The drag of the shrouded disc is very high in forward motion not only because of the profile drag of the shroud but due to the marked change in direction of the oncoming air from horizontal to vertical.

On the other hand, the unshrouded propeller does

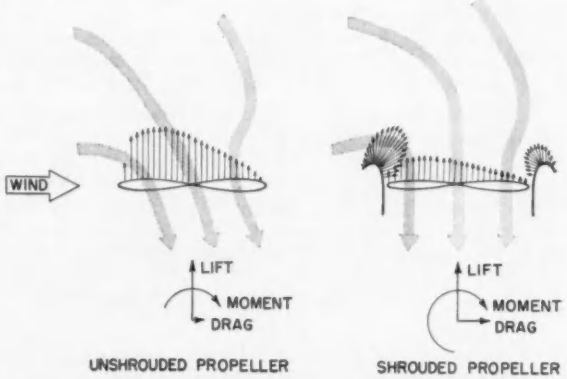


Fig. 1 — High moment and drag are typical of shrouded propellers in forward flight. The shroud gives better airflow distribution through the propeller disc, resulting in up to 25% increase in lift force in hovering flight.

Chrysler

Aerophysics

not impede the horizontal motion of the air (its drag is lower) and its smaller pitching moment is due only to uneven loading of the rotor. One result is that the unshrouded rotor does not have to be tilted forward as far for the same forward speed.

An example of the effect of this design compromise is the fact that the one unshrouded design uses a turbine engine to get a better power-weight ratio. Another design uses shrouds and a reciprocating engine but has to use turning vanes to overcome the high drag and tilt at forward speeds.

Choosing the Propellers

Aerophysics' choice of unshrouded propellers reflects concern over the forward flight conditions. For example, the drag on a shrouded propeller would be half the lift at 55 fps for the case of a 6-ft propeller lifting 800 lb. Positive pitching moments are large. In fact, for a typical propeller-shroud combination, the resultant force acts at a point a quarter-propeller-diameter forward of the disc center. These effects could be corrected by rotating the propeller housing or using turning vanes, but this adds complexity and weight.

As a result, a simple 4-propeller configuration was used.

Some of the advantages and disadvantages of this system are:

- The guards around the blades still provide about 4% thrust augmentation.
- The overall vehicle width can be reduced dur-

HERE are the general requirements the Army asked for when it looked for a flying platform to transport men and equipment:

- **Height as low as possible and width 10 ft or less. Four platforms should fit into a C-130 aircraft.**
- **Payload of 1000 lb, including pilot.**
- **A minimum of 50 nautical mile range with a normal cruise speed about 50 knots.**
- **Take-off from 3000 ft on an Air Force-Navy standard hot day.**
- **Operate on standard Army fuel or JP-4.**
- **Easy to maintain and insensitive to unskilled handling, such as uneven distribution of the payload.**
- **Travel as a ground vehicle for short distances.**

THIS article is based on the following papers:

What Is Required of the Aerial Platform? (Paper No. 10R)
by **Larry M. Hewin**
U. S. Army Transportation and Engineering Command

Stability and Control of Flying Platforms (Paper No. 10S)
by **M. O. McKinney**
NASA Langley Research Center

Aerophysics Aerial Platform, VZ-7AP (Paper No. 10T)
by **Robert W. Evans**
Aerophysics Development Division, Curtiss-Wright Corp.

Chrysler Aerial Research Vehicle Project (Paper No. 10U)
by **John V. Gorton**
Chrysler Corp.

Development of the Piasecki "Sky-Car" (Paper No. 10V)
by **F. N. Piasecki**
Piasecki Aircraft Corp.

To Order Papers No. 10R, S, T, U, or V ... on which this article is based, see p. 6.

the Army is getting flying platforms

. . . continued

ing storage by flipping up the guards and aligning the propellers fore-and-aft.

- Larger, more efficient propellers can be used because space for a shroud is not needed.
- Drag and flap hinges had to be added to the propellers to reduce the oscillatory loads. These loads are not as great in shrouded designs since the air always tends to approach the propeller perpendicular to its plan of rotation.

An example of the tilt angles that would be encountered with a shrouded design is given in Fig. 2.

Chrysler engineers stayed with a completely rigid propeller design. This lends itself to simple and economic construction. Trim and control are by vanes.

Piasecki also choose a rigid rotor but added cyclic pitch. This type of propeller has the advantage of providing a direct moment, independent of the center of gravity. Three-bladed propellers are used and the vibration characteristics are excellent.

Stability Is Critical

Stability in pitch and roll are the main problems to overcome in all types of designs. Shrouding the propellers emphasizes the problem.

An example is the pitching stability in forward flight. The platform is tilted forward to maintain forward flight. The controls are set so the vehicle is in trim. Now, an increase in velocity will give a nose-up pitching moment. Also, a decrease in angle of attack (the platform moving toward a horizontal position) will likewise produce a nose-up moment. If a slight disturbance occurs, say to tilt the nose up, instability occurs.

When the angle of attack decreased, a nose-up moment was created. This continues to tilt the platform toward a horizontal position. In so doing the thrust vector of the rotors becomes more nearly vertical and the platform slows down. This decrease in forward speed produces a nose-down moment. However, there is a time lag between the nose-up tilting and the slowing down. This lag is sufficient to allow the platform to overcorrect, first because of the tilting and then because of the velocity change. This cycle repeats itself and a divergent oscillation occurs as shown in Fig. 3.

The same thing happens in the roll direction, but the time for each oscillation is much shorter because of the smaller moment of inertia about this axis.

The same thing happens in the roll direction, but the time for each oscillation is much shorter because of the smaller moment of inertia about this axis.

The NASA ran tests to find how much control force is needed to keep the platform stable. For a 2000-lb platform 10 ft wide, the following approximate control accelerations are needed:

pitch = 0.6 radians/sec^2
roll = 1.8 radians/sec^2
yaw = 0.3 radians/sec^2

The low value of yaw acceleration reflects the ease with which this motion can be controlled. There are no unstable forces acting in this direction similar to the pitch and roll condition.

Two other effects are closely related to pitching stability. They are the downwash and pitching velocity influence on the pitching moment of tandem rotor designs. The downwash of the forward rotor reduces the lift of the second rotor. (See Fig. 4). This magnifies the nose-up pitching moment that must be trimmed out of the vehicle.

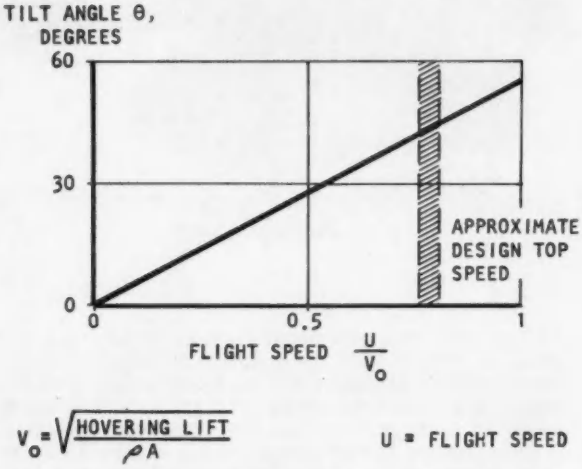


Fig. 2 — Shrouded rotor requires extreme forward tilt to overcome the high drag of the design. The angle of tilt can be reduced by deflecting the air leaving the rotors rearward. This can be done with turning vanes beneath the rotor.

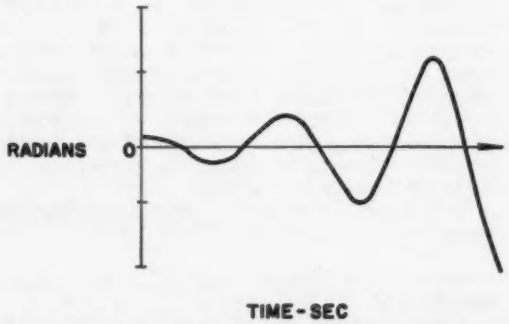


Fig. 3 — The flying platform is unstable in pitch and roll. Without corrective forces, the platform will oscillate as shown in either of these two directions.

The second action takes place when the platform is pitching. If a nose-up pitch is taking place, then the forward rotor will have a higher thrust and the rearward rotor a lower thrust. This tends to accelerate any tilting action.

Control Systems

The **Chrysler** vehicle uses a complete system of vanes or louvers for control, as shown in Fig. 5. There are four basic parts.

Pitch louvers located in the duct inlet produce nose-down and nose-up moments about the pitch axis when deflected by a fore-and-aft motion of the control stick. A cascade under the front rotor acts as a second part of this forward control system. This cascade deflects the air rearward and adds to the forward propulsive force. The result is a smaller tilting angle in forward flight and smaller nose-up pitching moments to trim out. This latter effect is because the line of action of the cascade is above the center of gravity. This is also the reason a cascade was not used on the rear rotor. In this case, the line of action should be below the center of gravity and aggravate the nose-up pitching moment.

The third and fourth parts are the roll and yaw vanes beneath each rotor. The roll is controlled by a lateral motion of the control stick and yaw by pilot's foot pedals.

The analog computer analysis of the vehicle indicates a two-axis stability augmentation system is necessary if driver fatigue is to be avoided.

Aerophysics designed their platform with direct control over roll, pitch, and yaw. Vertical climb is

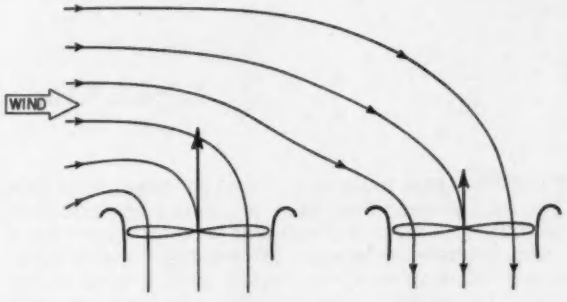


Fig. 4 — Downwash of forward rotor decreases thrust of rear rotor. This is partly due to the increase in vertical velocity of the air approaching the second rotor and partly a loss of suction on the lip of the shroud. The effect is to increase the nose-up moment of the platform.

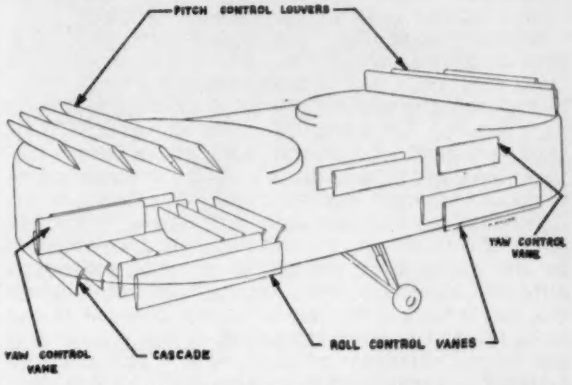


Fig. 5 — Pitch, roll, and yaw are controlled in Chrysler's aerial platform by a series of vanes. The cascade at the bottom of the front rotor helps forward propulsion and the trim of the vehicle. The cascade is not present on the rear rotor because this would tend to untrim the platform around the pitch axis.

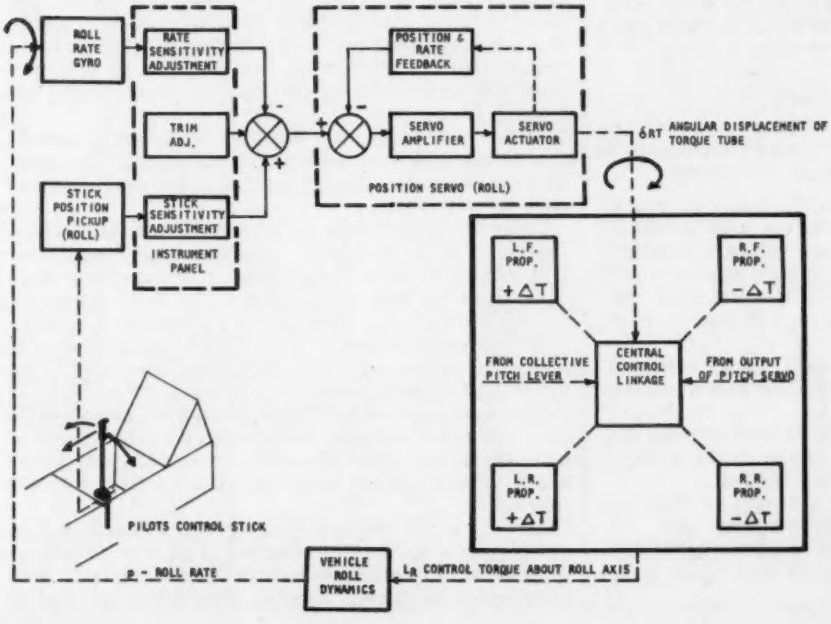


Fig. 6 — Artificial stability is practically a requirement for flying platforms. The Aerophysics system for roll is shown. A similar one is used for pitch stability. It is possible to control the vehicle manually but the resulting fatigue on the pilot would limit his usefulness.

the Army is getting flying platforms

. . . continued

accomplished by changing the collective pitch on the propeller blades as opposed to the Chrysler system of engine throttle control.

Pitch and roll result from differentially controlling the pitch of pairs of propellers. The collective pitch and differential pitch controls are linked together so that one control cable operates a hydraulic servo at each propeller hub. The blades of the propeller are actuated in a manner similar to conventional controllable pitch airplane propellers.

The yaw control system consists of foot pedals connected to a rudder in the turbine exhaust.

Stability augmentation is provided by a two-axis gyro system about the pitch and roll centers. A block diagram of the roll axis augmentator is shown in Fig. 6. In the experimental model, the system is very flexible, with features such as variable pilot stick sensitivity, adjustable damping, separate engagements of roll and pitch stability augmentation, variable trimming, and pilot override of augmenter.

Piasecki uses cyclic and differential collective pitch and vanes for control. Roll is accomplished by the cyclic pitch control on the two rotors. A different collective pitch on the two rotors gives the major part of the pitch control because of the large lever arm between the c.g. of the vehicle and the center of thrust of each rotor. The pitching moment is augmented by cyclic pitch. Yaw control comes from vanes beneath both rotors.

In the first flying "sky-car," there is no need for stability augmentation when a regular helicopter pilot is at the controls. However, augmentation in pitch and roll will undoubtedly be used if GIs are the drivers. With flight experience to date, the tilt angle at design forward speed is not objectionable. If developments step up the forward speed, a vane cascade may be used to control tilt.

Problems To Come

All of the vehicles under construction are intended for research. When a production design is finalized, it will have to include the following:

- Power Failures — Autorotation has not proved completely practical for helicopters and would be less so for flying platforms. Some possible solutions are two-engine vehicles, emergency stored power (such as a high-speed flywheel), tip jets that convert to ran jets, or even zero speed and altitude parachutes.
- Downwash — The dust blown up at low altitudes would be a military giveaway and a civilian irritation.
- Noise — This also has military and civilian disadvantages. In the same vein is the exposed flame, whether it comes from engine or tip jets.
- Simplicity — With the extra degree of freedom, the problem of driver education is a large one. Automatic controls will probably reduce manuverability if they approach the ease of driving an automobile.

Now we have

Solid-Film For 1000 F

Based on paper by

Ralph E. Crump
Electrofilm, Inc.

THE solid-film lubricant — a solid, fixed, thin film (usually less than 0.001 in. thick) composed of solid lubricants held together and in place by a suitable binder — has been developed for the lubrication of devices operating at 1000 F and above. (700 F is the maximum effective operating temperature of conventional lubricants.)

Among the various materials studied, the best combination was found to consist of particles of synthetic graphite and lead oxide, with a binder of porcelain enamel.

Actually, this combination represents a compromise because, although lead oxide has a low coefficient of friction at 1000 F (as low as that of graphite at room temperature), its coefficient is high at room temperature. Eventually, it is hoped this compromise can be abandoned in favor of a single solid lubricant in a binder.

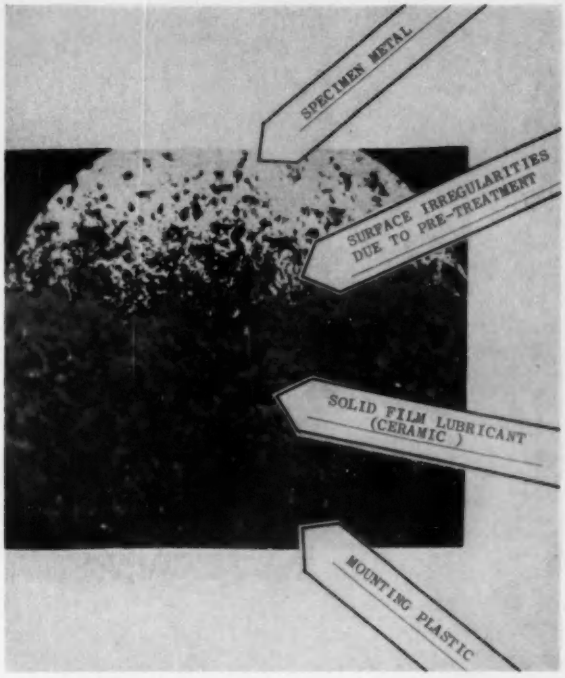
Water (with a small amount of wetting agent) has proved quite satisfactory for thinning the solid-film lubricant to a fluid consistency for easy application to the metal.

Prior to application of the lubricant, the metal surface should be pretreated to ensure cleanliness and adhesion. Fig. 1 describes a typical sequence to be used for such processing. The light sandblast (using 120 grit dry sand, 40 psi) provides a surface with enough developed area (32–64-microin. finish) to assure better adhesion than that obtained if no sandblasting were used.

The most successful formulas to date use so little frit — dry, unfired porcelain enamel — that the end product is not glass-like on the surface but grey-black, when graphite and lead oxides are used as the lubricant.

The microphotograph (on page 45) shows a section cut through the ceramic-bonded solid-film lubricant on a taper. The purpose of the taper cut is to amplify cross-sectional details. The light section at

Lubricants Applications



Microphotograph of a section cut through the ceramic-bonded solid-film lubricant on a taper.

the top is the Inconel X specimen metal. The irregular light and dark intermediate area is the interface between the film and the metal. The roughness is due to the metal pretreatment prior to the application of the lubricant. The dark area is the film of ceramic, graphite, and lead oxide. (This film was cured at 1000 F, for 15 min, prior to the cutting and mounting.)

Table 1 shows the coefficient of friction of the ceramic-bonded solid-film lubricant on several metal combinations.

To Order Paper No. 4S . . .
. . . on which this article is based, turn to page 6.

Table 1 — Coefficient of Friction of Ceramic-Bonded Solid-Film Lubricant on Several Metal Combinations

Metal — Lubricant — Metal		Coefficient of Friction			
		Specimen Coated Only			Uncoated
Specimen	Block (Bare)	75 F	750 F	1000 F	1000 F
Hastelloy C	Hastelloy C	0.320	0.320	0.320	0.540
Hastelloy C	Ni Resist II A	0.280	0.330	0.360	0.440
Hastelloy C	AISI 440C	0.380	0.340	0.320	0.490
Stellite 6	AISI 440C	0.250	0.430	0.420	0.470
17-4 PH	Geek Ascalloy	0.250	0.290	0.350	0.670
17-4 PH	Stellite 31	0.280	0.300	0.390	0.670
Steel (Uncoated)	Inconel X	0.119		0.177	0.360
		75 F	850 F	1100 F	
75A Titanium	75A Titanium	0.160	0.080	0.080	
A286	AISI 440C			0.090	
440C	SS 410			0.090	

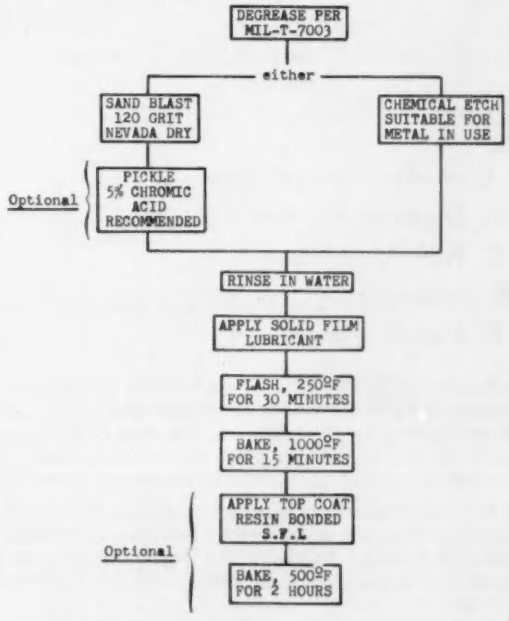


Fig. 1 — Recommended processing procedure for application of ceramic-bonded solid-film lubricant to metals to be operated at high temperature.

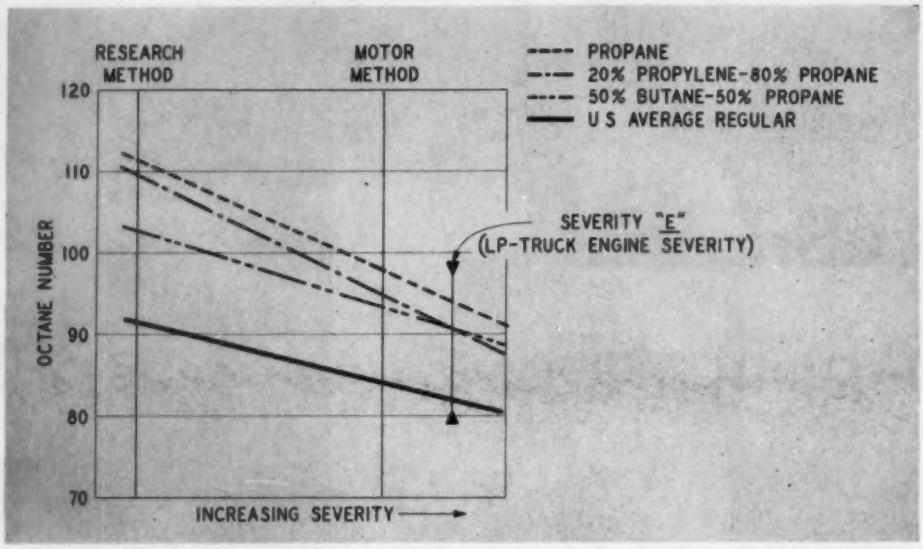


Fig. 1 — Nomograph showing relative severity of full-scale truck and laboratory engines. This nomograph can be used to find out if an LPG blend of known composition can meet severe truck engine knock requirements.

LPG Octane Number Is

Based on paper by

W. G. Armor, International Harvester Co.

H. D. Ingerson, Reo Division, White Motor Co.

A. G. Hilf, Highway Products

J. N. Jobaris, Chicago Transit Authority, and

H. E. Alquist, Phillips Petroleum Co.

COOPERATIVE investigations of the relationship between LPG characteristics and the knock-limited performance of several truck and bus engines over a range of design and operating conditions have three accomplishments to report at this time:

- A nomograph has been devised whereby one can determine whether a particular LPG blend of known composition has a high enough octane rating to be suitable for use in the most severe heavy-duty truck engines.
- It was demonstrated that if carburetor air or mixture temperatures are not held within reasonable limits, satisfactory knockfree operation will not be attained in all heavy-duty engines, even with pure propane.
- It became evident from the unique knock-limited characteristics of LPG in heavy-duty engines basically designed for gasoline that a new approach is required to design mechanical octane numbers specifically for gaseous fuels.

The Nomograph

Fig. 1 is a nomograph for determining the suitability of LPG blends of known composition for meeting the octane requirements of the most severe truck engines investigated in the program.

The nomograph can be used in conjunction with Table 1, which gives the Research and Motor octane numbers of possible LPG components.

The octane number of the blend under consideration can be calculated by substituting the proper values in the following equation:

$$\text{Blend O.N.} = \frac{\%A \times \text{O.N.}_A + \%B \times \text{O.N.}_B}{100}$$

where:

%A, %B = Liquid volume per cent of A, B
O.N._A, O.N._B = Octane number of A, B

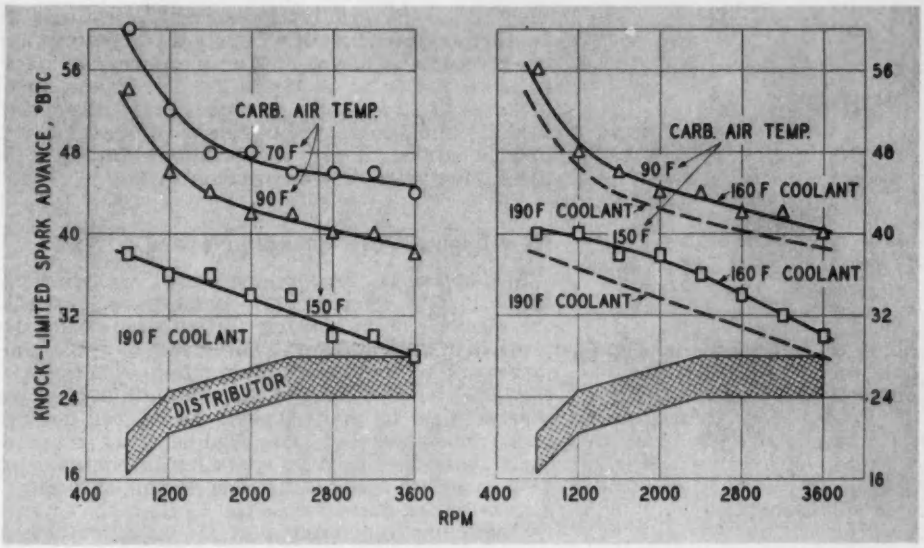


Fig. 2 — Effect of carburetor air and engine coolant temperatures on knock-limited spark advance available with propane. (Engine with 7.96 compression ratio.)

Important, too!

With this equation, determine the Research and Motor octane numbers of the blend. (Table 2 gives values for a large number of such blends.) Plot these values on Fig. 1. Extend the line through these two points until it crosses the line marked "Severity E." Then read the "Severity E" octane number. The three most severe truck engines investigated had an octane number of 90.5 on the "Severity E" line. Thus, any blend having an octane number on this line of 90.5 or more should be suitable for any truck engine operating today on LPG.

Carburetor Air Temperature

Sufficient data have been obtained on these engines to demonstrate that if the inlet temperature is not controlled to reasonable limits by drawing air from outside of the hood and using cold intake manifolds, specifying LPG antiknock quality is of little value. In fact, evidence has been obtained to suggest that field knock problems experienced on some truck engines during the summer of 1957 could have been due to excessive inlet temperatures as well as high propylene content.

Even with the best manifold design and external

Table 1 — Octane Numbers of Possible LPG Components

	Research	Motor
Propane	111.4	97.1
n-Butane	94.0	89.1
Propylene	101.8	84.9
Ethane	111.5	100.7
Iso-Butane	102.1	97.6
Iso-Pentane	93.0	89.7

Table 2 — LPG Test Blends (Percentages are for liquid volume)

	Research	Motor
90% Propane + 10% n-Butane	109.7	96.3
75% Propane + 25% n-Butane	107.1	95.1
60% Propane + 40% n-Butane	104.4	93.9
50% Propane + 50% n-Butane	102.7	93.1
40% Propane + 60% n-Butane	101.0	92.3
92% Propane + 8% Propylene	110.6	96.1
80% Propane + 20% Propylene	109.5	94.7
53% Propane + 47% Propylene	106.9	91.4

LPG Octane Number

Is Important, too!

. . . continued

air source there are going to be periods — particularly southwestern U.S. summers — when the air going to the engine combustion chambers will be on the order of 120–140 F. Under such circumstances an effective method of charge cooling is to utilize the latent heat and expansion cooling available from the LPG itself. This can be done by substituting a heat exchanger in the carburetor air duct as an alternate to the present converters, which merely help lower the engine coolant temperature. The relative merits of lowering the carburetor air temperature versus lowering the engine coolant temperature are brought out in Fig. 2. It will be noticed that, consistent with previous experience on liquid fuels, a given change in air temperature is about twice as effective as the same change in jacket temperature in raising the knock limit of propane in the engine with 7.96 compression ratio. The practicality of attaining inlet temperatures as low as 70 F by LPG expansion and vaporization was checked in the Phillips Research Laboratories on another engine where it was possible to get mixture temperatures as low as 60 F with ambient temperatures on the order of 95–100 F. The improvement in knock-limited spark advance for propane with this air temperature reduction to this engine was in good agreement with the data shown in Fig. 2 for the engine with 7.96 compression ratio.

New Engine Developments Needed

In addition to these temperature considerations, there is one other factor which may outweigh everything else in causing the apparent excessive severity in these engines. The curves of knock-limited spark advance versus rpm obtained on most of the LPG blends in most of the engines have just the reverse slope to that obtained on all full-boiling-range gasolines and pure hydrocarbon reference fuels. Since the optimum spark for an engine using LPG increases with an increase in rpm, this unique knock-limited curve forces the LPG engine to have its maximum requirement at its maximum speed. Thus, it appears that a real contribution to the mutual adaptation of LPG to engines and vice versa will await engine developments which will flip the knock-limited spark advance versus rpm curve for LPG blends to a characteristic more like ordinary liquid hydrocarbons. It is quite evident that mechanical octane-number designs for liquid and gaseous fuels are horses of two different colors.

To Order Paper No. 6U . . .
. . . on which this article is based, turn to page 6.

Heavy-duty truck engines using LPG have been plagued with knock since about 1957.

The first engines converted to LPG in the early '30's operated without knock, just as early automobile and aircraft engines worked happily on a variety of petroleum spirits. But LPG-engine problems have gone the route of increasing knock problems, as did their earlier automotive counterparts.

Lately, truck manufacturers have been forced to take such measures as:

- Reducing LPG engine compression ratios.
- Limiting regular LPG engine conversions to local-service types of operation.

At the same time both formal and informal requests were being made for consistent LPG antiknock quality control throughout the country.

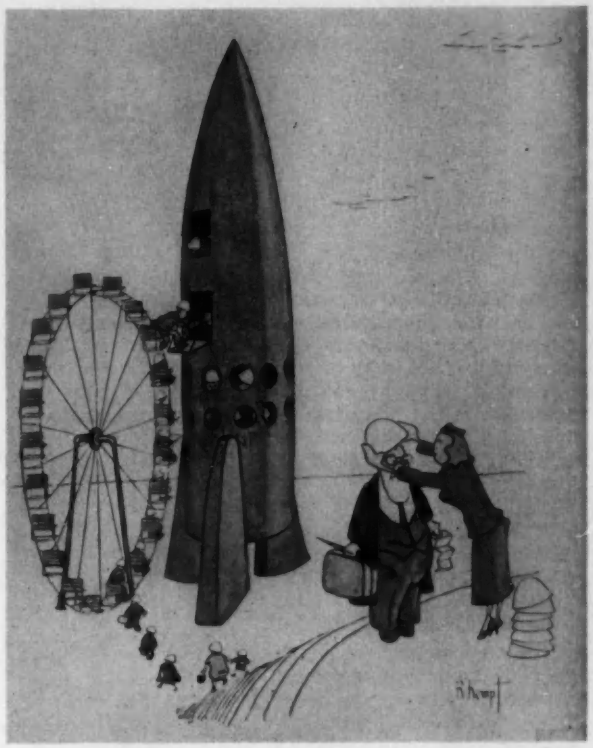
Recognizing the need for a thorough investigation of the problem, a group of companies, represented by the authors of this article, decided to conduct a cooperative program designed to answer the following questions:

- What are the LPG antiknock quality requirements of heavy-duty commercial engines now in production?
- What are the effects of variation in design and operating conditions on these antiknock requirements?
- What are the antiknock characteristics of the various LPG blends in these commercial engines?

The accompanying article gives briefly their findings and recommendations.

The complete paper on which this article is based presents in detail the progress to date.

Manned Space Flight Is Coming



Based on paper by **Robert D. Roche**
Lockheed Aircraft Corp.

MANNED systems will play a large role in aero/astronautics of the future; the next generation will find itself participating in the operation of aero/space vehicles out of necessity and desire. This era, almost upon us, is no longer Sunday supplement material.

At the same time, the capability of unmanned systems cannot be ignored. Already they have played a large, important role in military and scientific fields, and will continue to do so. But in so far as progress is concerned — measured at the highest level and including subdivisions such as military need, scientific progress, and prime adventure — unmanned systems are a necessary digression from the mainstream where man's direct participation is a fundamental requirement.

manned systems defined

The phrase "manned systems" refers to those systems in which a human being actively participates in the control and operation of the vehicle. By unmanned systems is meant those systems remotely controlled and guided, and in which mission tasks are programmed and controlled electronically by telemetering links to earth. Moreover, the vehicles to be considered here as "systems in aero/astronautics" are limited to those of the next generation with the capability of both aerodynamic flight and travel in space. Fig. 1 shows some operational aspects which help define the systems.

These systems must re-enter the atmosphere to bring the crew back to earth. The methods being considered currently use parachute return; in this case only the thermal limitations are significant. However, it is desirable for many reasons to have aerodynamic flight return to earth. This requires some type of wing to provide lift at speeds permitting approach to an airport. This sharp restriction on the speed/altitude performance is shown in the diagram in the lower part of Fig. 1. The reentry phase of flight will be accomplished within the corridor shown, in a manner not much different from conventional aircraft operation today.

The speed/altitude problems for the space portion of the flight are shown in the upper diagram (on a very different scale). At any given altitude (the ordinate) a certain speed (the abscissa) must be attained to permit either orbiting, as in the case of satellites, or escaping the earth's gravitational field, as in the case of the Russian Lunik. (A curve for the speeds required to escape the sun's gravitational field is not shown.)

For high speeds at low altitudes, there is a thermal barrier based upon the maximum temperature that materials can stand. At higher altitudes the lack of atmosphere obviates the thermal barrier,

Manned Space Flight Is Coming

... continued

but the high speeds still impose a limit due to the time-acceleration man can stand. Also shown is an upper limiting curve which is related to the time required for the mission. If the destination is very distant, and speed only moderate, more time than man will tolerate may be required. The curve shown is based on 20 years maximum for a round trip. We have, therefore, bounded an area of speed/altitude combinations which will permit escape, slow and high enough to prevent burnup and acceleration damage, yet fast enough to get there and back in 20 years. The aero/space vehicles having these characteristics are basically missiles, with engineering differences, and we consider here the necessity for manning them.

At this point it is necessary to make three assumptions. These are:

1. Both types of aero-space vehicles are feasible; they can be designed, built, and operated.
2. Both types are desirable and practical. They will be produced and operated in, roughly, the next 20 to 40 years.
3. The vehicles are capable of being operated either by man or by remotely controlled electronic systems.

These assumptions are reasonable and agreed to by a majority of experts, though opinions may differ as to the time period. There remains the question whether the systems should be manned, and this will be considered from three points of view — military, scientific, and prime adventure.

military viewpoint

It is possible to make a case for manned systems in the near future based only on superior performance of man over machine. Arguments include such points as: man's ability to deliver a warhead more accurately to a target; increased operational reliability due to man's inflight monitoring and maintaining of equipment, and higher probability of penetration of enemy defenses due to greater maneuverability of a manned vehicle. The counter argument — and a valid one — is that engineering skills are such that, given time and money, they will make a machine perform each of these operations as effectively as man.

Experts in this field, notably Dr. George E. Valley, chief scientist, USAF, and General James Ferguson, director of requirements, USAF, have forcefully pointed out capabilities of manned weapons systems. The argument bases on man's ability to (1) steer the vehicle, (2) act aggressively, (3) respond to unexpected situations, and (4) convert abstract ideas into concrete action. These functions are related to the more fundamental capabilities of man to exercise judgment, discretion, and decision-making skill. These provide a flexibility in tactics that unmanned vehicles cannot approach.

There are something like 200 research study programs in progress that involve man in space. Design and development programs are daily bringing us closer to the actual hardware. The Lockheed F-104 Starfighter has reached the fringe of space. In May 1958, it broke all speed records by traveling over 1400 mph, and the altitude record of over 91,000 ft, to become the first manned aero/space vehicle.

Three examples will serve to indicate the seriousness of the intent to have manned aero/space vehicles. These are:

- The B-70 Air Force bomber, powered by chemical fuels of a special nature. It will fly above 70,000 ft and faster than 2000 mph. Air friction may raise skin temperatures to more than 900 F. Four men will occupy a sealed cabin quite similar to spacecraft compartments.
- The X-15, an experimental system that will be dropped from an aircraft and rocket up into space for several minutes. Part airplane, part rocketship, the mission profile calls for altitudes of over 100 miles and speeds over 3600 mph.
- Dyna Soar, shown in Fig. 2. This is a pilot-controlled, bomber-reconnaissance space vehicle of

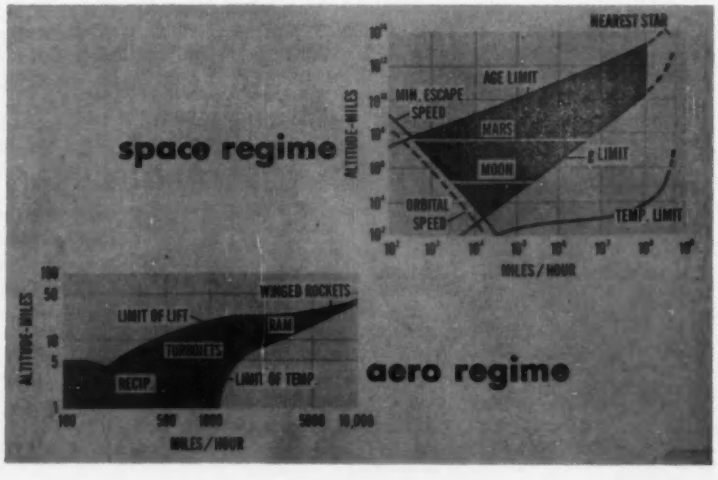


Fig. 1 — Operational aspects of aero/space vehicles of the future, which will have the capability of both aerodynamic flight and travel in space.

which the X-15 is the forerunner. It will be boosted by rocket power to altitudes and hypersonic speeds permitting circumnavigation of the earth, after which the crew will skip-glide the vehicle to home base. This is the predecessor to the orbital manned bomber.

manned systems for scientific purposes

For the collection of technical data of known types, there is no doubt of the superiority of unmanned equipment in many situations. In many areas of experimental research and actual operations, the human being is completely superfluous. In some cases where he does perform a function, a machine monitors him. On board vehicles a man can be replaced by five miles of photographic film for the same space and weight considerations. So why have a human crew?

There is one outstanding factor justifying human operators and observers in aero/space vehicles. It is the greater probability of unexpected events occuring on scientific voyages into space than on earth-bound research in which we are reasonably well informed. It is fact that there is little or no fundamental knowledge of the extra-terrestrial physical sciences. There are only theories, usually several for each phenomenon observed.

The number of scientific problems still unsolved is impressive. On the matter of gravitation, we have only working hypotheses. These have been useful, but as we consider weightlessness of steel, aluminum, and other materials, and the possibilities of using force fields to achieve it, we face the fact that we don't know the nature of gravity or even the fundamental source of our own earth's force of attraction.

A familiar problem and vital to guidance systems is the precise measurement of distance on the earth's surface. We do not know the location of Moscow with an accuracy within four miles, so the accuracy of our measures of the distance between earth and other planets can be imagined.

Scientists are approaching a theory of the earth's magnetic field which holds real promise, but we don't yet know from direct observation the source of the force, nor the driving power that maintains it. Solar radiation is still another example of an area in which our scientific knowledge is far short of what is desired.

For all we know there are force fields in space which solve all secondary power supply problems in interplanetary travel. There may be interstellar drives of a nature completely foreign to us. It is inconceivable that such phenomena could be uncovered in a reasonable time period by automatic probes, even if highly sophisticated, though these are the essential first steps. The history of scientific progress is replete with unanticipated events that provided the key to a scientific theory not even under investigation. How else but with a man aboard can the space system observe a phenomenon, decide it is interesting, judge it to be of value, and proceed to investigate it.

The scientist is going to be put in his space laboratory and one example of the many plans and programs underway to do it is shown in Fig. 3. This is an artist's conception of a space station — a permanent orbiting satellite, generating its own heat and light, with a complement of men aboard. It is a unique astro-tug for assembly of the system. Reentry vehicles which shuttle back and forth to earth are also shown.

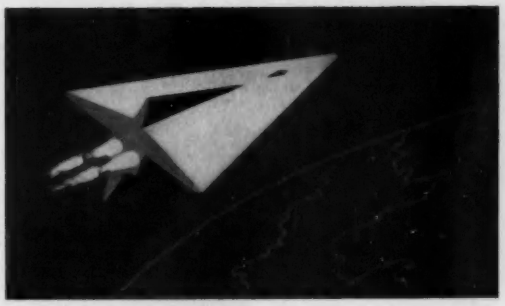


Fig. 2 — This projected pilot-controlled, bomber-reconnaissance space vehicle, called the Dyna Soar, reflects the serious intention to have manned aero/space vehicles. This predecessor of the orbital manned bomber will be boosted by rocket power to altitudes and hypersonic speeds that will allow circumnavigation of the earth and a skip-glide to home base.

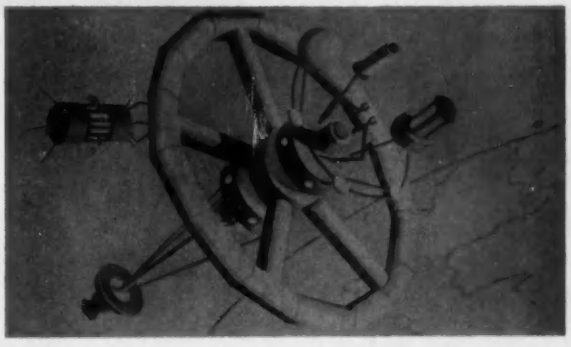


Fig. 3 — Lockheed's astro-tug and space station represents one idea for putting the scientist in space. This is a permanent orbiting satellite, supplying its own heat and light. The artist has included shuttling reentry vehicles.

the factor of prime adventure

For those who remain unconvinced that man will be needed aboard aero/space vehicles a few years from now, there remains the prime adventure point of view — one that looks long and hard at the nature of man and his psychological drives.

Man's insatiable curiosity and his incessant goal-seeking activity, two prime psychological drives, have caused him to embark on new adventures and to make discoveries purely for the gratification of his desire for greater knowledge about his environment and himself. Modern man's desire to explore space is as natural an outgrowth of his make-up as was his stone-age counterpart's desire to roam his immediate countryside to see for himself what was there.

It seems reasonably safe to say that whether military requirements exist, or whether pure scientific research goals must be attained, aero/space vehicles will carry human crews just because man is designed the way he is.

To Order Paper No. 615 . . .
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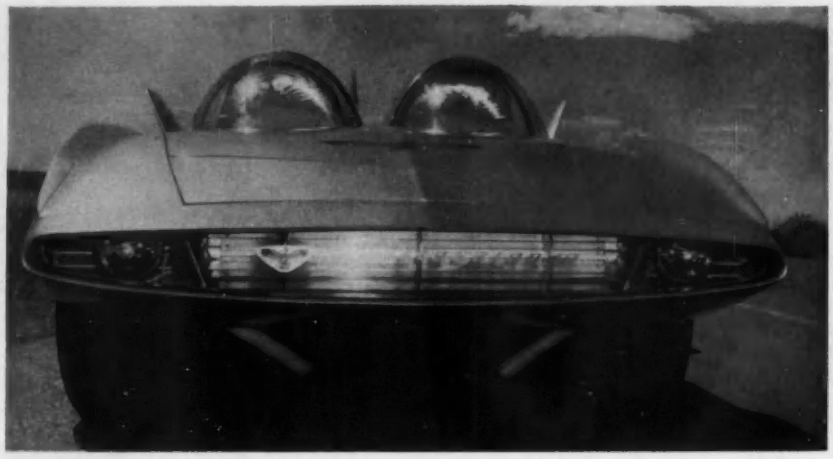


General Motors' Firebird III

FIREBIRD III, incorporates many advance design characteristics in its chassis, powerplant, and external appearance.

Fundamentally different car control means are used, including both manual and automatic devices. High capacity brakes have been provided with skid control to achieve maximum braking effort. A new suspension and springing system provides accurate lateral control plus efficient reduction of road disturbances. A separate powerplant of unique construction drives generators and pumps to provide power for the vehicle's control system. The rear axle and the transmission use the same lubricant. And, the power transmission from the main propulsion engine to rear wheels has been designed to obtain optimum car performance by matching it to the GT-305 gas turbine engine.

frame

The frame of Firebird III (Fig. 1) was designed to handle all of the structural loads. The central spine construction through the passenger space serves as a mounting for the Unicontrol system.

Support for the auxiliary engine and the four-link front suspension is provided by two frame extensions attached to the center spine through an integral cowl and wheel-well unit. Behind the passenger compartment the frame is formed into a yoke, the front end of which serves to accommodate the air intake silencer for the gas turbine engine.

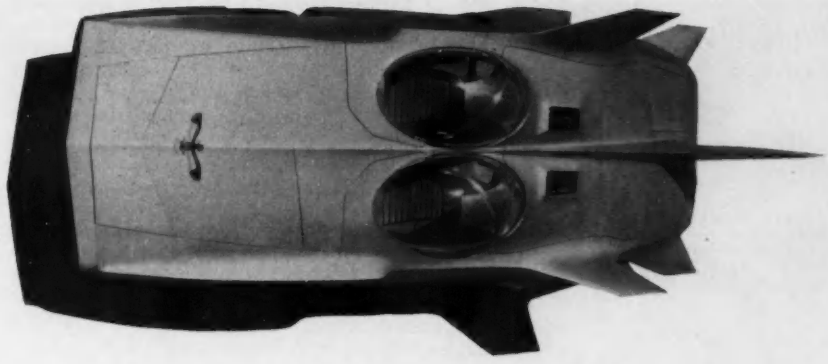
The frame's total weight has been held to 450 lb by use of light gage metal and deep sections which provide the necessary rigidity.

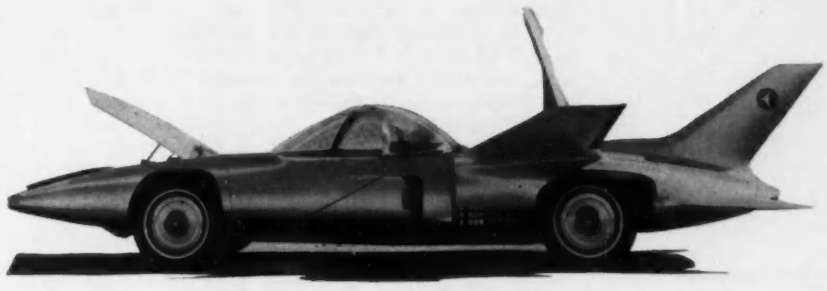
suspension system

Geometric roll steer is avoided on both front and rear axles of the Firebird III to prevent undesirable transient characteristics. Weight distribution and tire cornering properties produce approximately neutral static steering performance.

The front suspension geometry is shown in Fig. 2. A solid axle joins the two front wheels. The axle is joined to the frame by a four link suspension the two lower arms of which are parallel and horizontal and attach to the underside of the front frame extensions. Two upper arms are positioned at 45 deg to the centerline of the car in the horizontal plane and inclination in the vertical plane is arranged to provide 85% antidive. This construction permits a roll center height of 18.25 in.

The steering linkage is shown in Fig. 3. No caster or camber angle has been provided and the king pin inclination of 6 deg 38 min results in no offset at the intersection of the tire and the ground. These





geometrical values were selected because the steering system is irreversible with forces between the tire and the road not transmitted back to the steering control.

The power cylinder is attached to the front axle and operates an idler arm pivoted from the axle. Tie rods from the idler arm are connected to steering arms attached to the front wheel spindles. The geometry of this linkage provides Ackerman steering of the two front wheels.

The only connections between the steering mechanism on the axle and the sprung mass are electric wires and hydraulic hoses. Front wheel steering angles are unaffected by relative motion between axle and chassis. Front wheel angle information is provided for the servo by a potentiometer mounted on the axle and coupled to the steering linkage.

The solid front axle provides a high maximum cornering force and a high roll center while assuring that the wheels remain perpendicular to the ground regardless of the relative motion between the wheels and the chassis. The stiff electro-hydraulic servo positioning of the front wheels and elimination of mechanical steering coupling between axle and frame solves shimmy and roll steer problems.

The rear suspension shown in Fig. 4 is a De Dion type with the axle tube controlled by four links to

THIS ARTICLE is based on the following papers:

Firebird III General Arrangement and Body Design (Paper No. 24R)
Robert F. McLean and Stefan Habsburg
General Motors Styling Staff

Chassis and Control Details of Firebird III (Paper No. 24S)
J. B. Bidwell, R. S. Cataldo, and R. M. Van House
General Motors Research Laboratories

The GT-305 Regenerative Engine in Firebird III (Paper No. 24T)
W. A. Turunen and J. S. Collman
General Motors Research Laboratories

To Order Papers Nos. 24R, 24S, 24T . . .
. . . on which this article is based, turn to page 6.

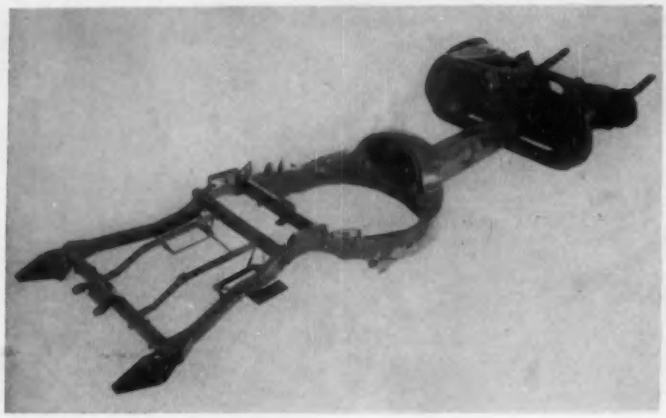


Fig. 1 — Firebird III frame.

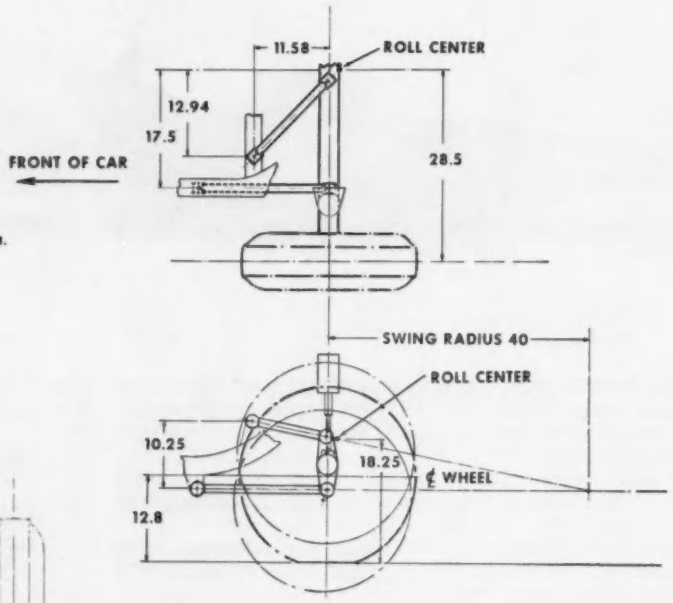


Fig. 2 — Front suspension.

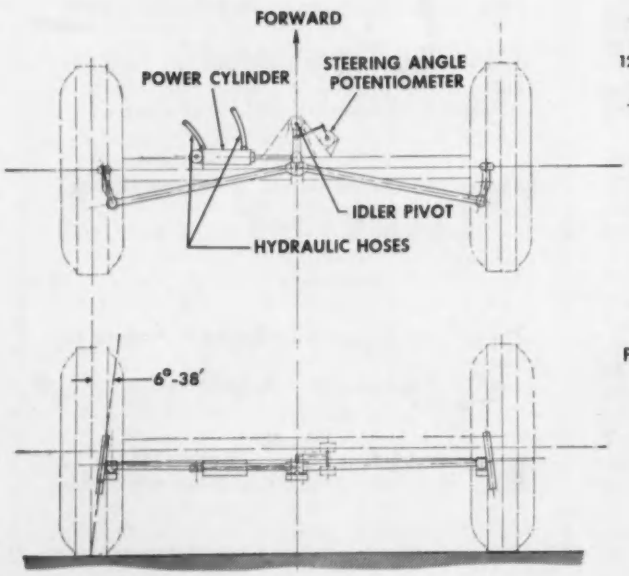


Fig. 3 — Steering linkage.

the chassis frame. Again, the lower arms are parallel and horizontal to provide zero roll steer effect while the upper arms are splayed at 45 deg to the car centerline and are inclined sufficiently in the vertical plane to provide a 60 in. swing radius. This swing radius provides 44% "anti-squat" without introducing brake or power hop problems. The rear roll center height is 19 in.

The large diameter connecting tube kicks up over the transmission between the wheels. It is fabricated of 0.078 in. stock to provide high rigidity with low unsprung mass. The underside of the tube is slotted to permit the independent wheel driveshafts to join the wheels to the rear axle. The c.g. of the finished car comes very close to the high roll axis reducing the moment arm of the mass and thus lowering the roll couple under conditions of side acceleration. This suspension design results in very flat cornering characteristics.

Dimensional Data and Chassis Specifications of Firebird III

Wheelbase	119 in.
Tread	57 in.
Curb weight (fuel and oil)	5275 lb
Weight distribution	46% front 54% rear
Tire size	8:00 × 14 front 8:50 × 14 rear
Running clearance	6.35 in.
Overall length	248.4 in.
Roll center height	18.25 in. front 19.0 in. rear

springs

Firebird III is sprung on air-oil springs which utilize air trapped in small accumulators as the elastic medium. The spring unit is shown in Fig. 5. To produce low rate springs of small physical size, the suspension system was designed to operate from a 3000 psi source. As a result, the spring cylinders are only about ¾ in. in diameter and the accumulators designed to provide 23 in. static deflection have a volume of only 18 cu in.

A single leveling valve at the rear of the car, and leveling valves connected to each of the lower arms of the front suspension regulate the standing height of the car. The front and rear springs are interconnected as in Fig. 6 to reduce the pitching stiffness of the suspension and reduce the single wheel rate while maintaining a reasonable roll rate. This connection permitted selection of suitable bounce, roll, and pitch stiffnesses to provide good ride characteristics without the use of roll bars and without sacrifice of handling performance.

A solenoid lockout operated by longitudinal acceleration closes the interconnection line during rapid acceleration or hard braking providing addi-

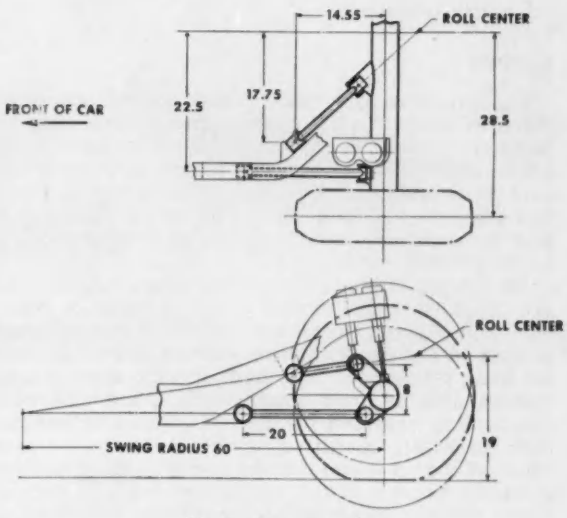


Fig. 4 — Rear suspension

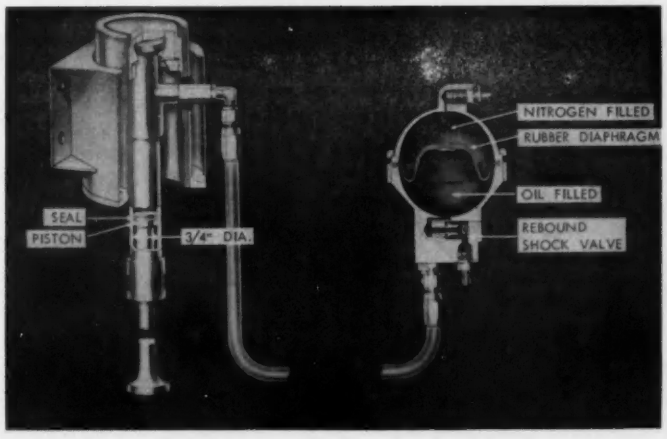


Fig. 5 — Air-oil spring unit.

tional pitch rate to supplement the geometric anti-dive and anti-squat in controlling car attitude. Since the main front and rear suspension springs cannot accommodate changes in weight distribution because of their interconnection, additional springs are located at the rear of the car to provide the necessary pitch reference.

Because of the interconnection of front and rear springs the spring rate at each wheel is influenced by motion of the other. Thus the single wheel rate is doubled when front and rear wheels are simultaneously deflected.

brakes

Enough braking capacity and control are provided in Firebird III to permit rapid dissipation of large amounts of energy during high speed deceleration and optimum braking under poor road-tire contact conditions. The first of these characteristics was achieved by design of the brake mechanism and the second by incorporation of skid prevention in the control system.

Aluminum brake drums integral with the wheels are provided with internal cored passages to function as a centrifugal blower. Sprayed molybdenum is used on the drum rubbing surface to provide better wear resistance. The high specific heat of aluminum and its good conductivity, combined with the cooling provided by the centrifugal blower results in brake operating temperatures well below those of conventional brake construction. Stainless steel tire flanges sealed with epoxy resin at the inboard side and by an "O" ring on the outside serve as heat dams to further reduce the tire bead temperatures.

The brake mechanism is a twin cylinder two trailing shoe type with sintered metallic linings. No self-actuation is required with this design since the wheel cylinders are energized directly from an active hydraulic power supply. Absence of self-actuation minimizes variations in braking torque resulting from variations in friction between the wheel and drum. Thus uneven braking and the resulting steering moments are reduced. The nominal brake size is 11 × 4 in. and the weight of a complete wheel and drum assembly is about 32 lb.

accessory power

Both electrical and hydraulic accessory power is utilized for control functions in Firebird III. All of the accessory devices are mounted together and driven by a specially designed four stroke-two cylinder opposed engine. The engine and accessory assembly are shown in Fig. 7. Use of this constant speed drive independent of the main engine permits smaller and more efficient accessory components and maintains full output of the hydraulic system and air conditioning under idling conditions, as well as with the vehicle running.

The engine is unique in having cylinders with integral heads cast of a wear-resistant aluminum alloy which operate without any special coating on the cylinder bore surface. The engine has a displacement of 20 cu in. and develops 10 hp at 3600 rpm using a compression ratio of 11:1.

The engine drives and is mounted to a 115 v, three-phase a-c generator. A 12 v generator, a 1000 psi and a 3000 psi hydraulic pump, and an air conditioning compressor are all mounted to the generator frame and belt driven from the rear of the generator shaft.

The 115 v generator supplies power for air conditioning blowers, engine compartment blowers, and the fluorescent low-beam headlight. The 12 v generator is a three-phase alternater which charges the car's 12 v battery system through silicon diode rectifiers. A transistor voltage regulator controls the d-c system voltage. A 1000 psi hydraulic pump is mounted above the 115 v generator to supply the servo hydraulic systems which control steering, brakes, and throttle, as well as air brake flaps. A

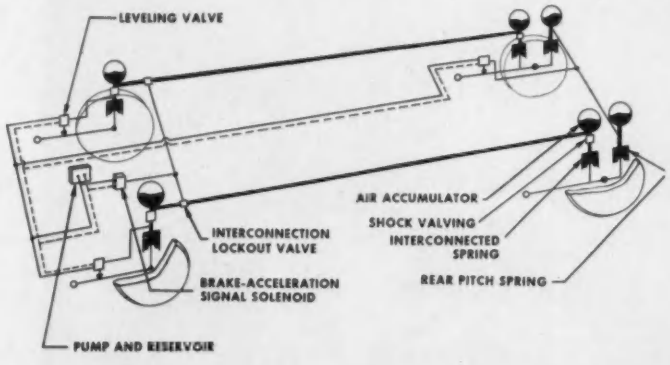
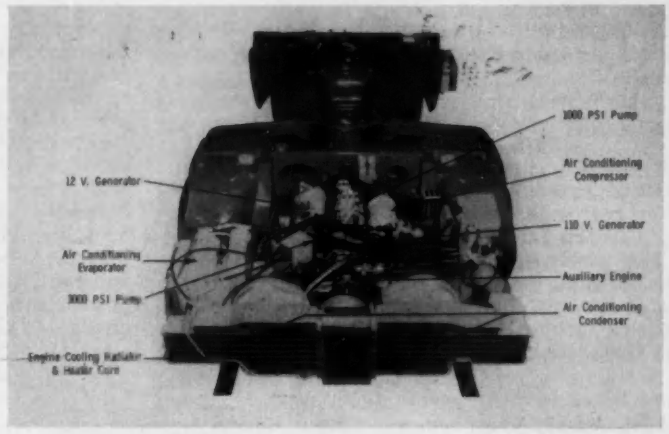


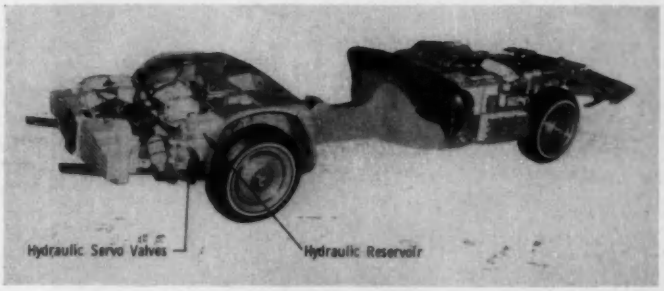
Fig. 6 — Interconnection of front and rear springs.

Firebird III Chassis Showing Component Location.

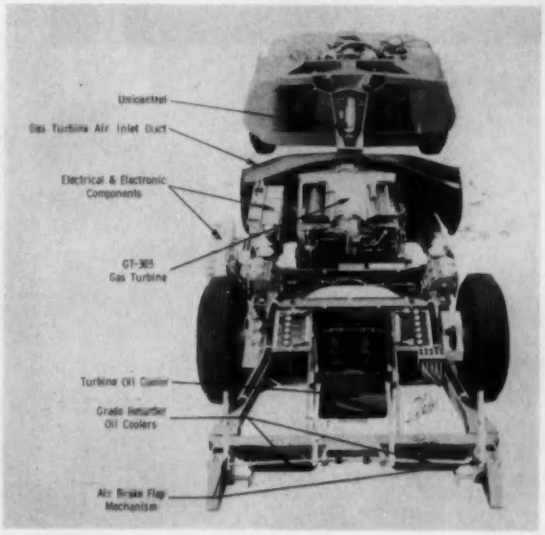
The front compartment (top) is utilized primarily for the auxiliary engine and all of the vehicle accessories. Across the front of the car is the air conditioning condenser divided at the center to accommodate a heat exchanger core which serves both as the auxiliary engine radiator and as the heater core for the passenger compartment.



The auxiliary engine, with its integrally mounted air conditioning compressor, 110 v and 12 v generators, and hydraulic pumps, is centrally mounted between the frame side rails. The air conditioning evaporator, blower, and air valves are located forward of the right front wheel well. A hydraulic reservoir and servo valve manifold (center) occupy the space ahead of the left front wheel well. The single backbone section of the frame through the passenger compartment accommodates the car control mechanism and provides space for hydraulic hoses and electrical wires between the front and rear of the car.



The GT 305 gas turbine engine (bottom) with its integral transmission, rear axle, and retarder, is located in the rear compartment just behind the passenger space. Air inlet ducts are mounted on top of the frame which incorporates an integral inlet silencer. Electrical relays and electronics equipment for communications and car control are located at the left of the engine and ahead of the rear wheels. Two 12 v batteries and a gas turbine engine oil cooler are centrally located just behind the rear axle. The blowers on the engine oil cooler also serve to circulate air through the rear compartment. At the rear end of the frame are located two small coolers which serve to reject grade retarder energy. Air brake flaps, both above and below the body, serve both a braking function at high speed and to duct air through the grade retarder coolers.



small 3000 psi pump attached to the end of the 12 v generator provides hydraulic power for the spring suspension.

power train

The power train from the engine to the wheels consists of a modified four-speed Hydramatic transmission, rear axle, and grade retarder mounted integrally to the turbine reduction gear output (Fig. 8). The power turbine is connected to the rear wheels through the gearing of several intermediate elements without any fluid coupling in the system, the power turbine serving this function.

The transmission shift points were selected after analytically determining the optimum gear ratios for maximum acceleration, taking into account the gas turbine transient characteristics. These differ from conventional piston engine characteristics principally in acceleration lag of the gasifier section which limits turbine torque and power until design speed is reached.

A rotary switch on the Unicontrol knob, the driver's stick control mechanism, operates an electrically driven ball nut to move the transmission manual selector valve. Only two positions of this valve are necessary, "drive" and "reverse", since the power turbine serves as a coupling and is always connected to the rear wheels. A "park" position on the Unicontrol switch energizes a grade retard sole-

Fig. 7 — Auxiliary engine and accessory assembly.

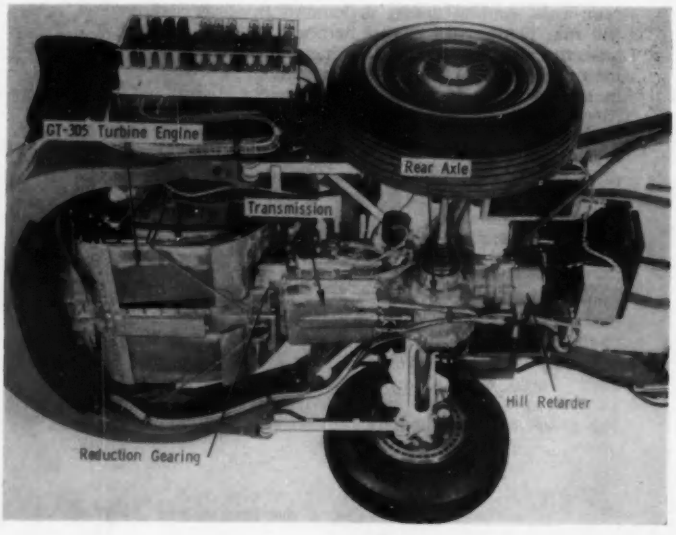


Fig. 8 — Arrangement of power train components.

noid and locks the rear wheels. This same switch provides a low idle speed in "park" and a high idle in "drive" or "reverse" by different bias signals to the throttle servo.

rear axle

The 3.41:1 ratio rear axle with spur gear differential is attached to the rear of the transmission. **The same lubricant is used in the rear axle as in the transmission,** eliminating the need for seals. The wheel drive shafts are connected to the rear axle through pot-type universal joints permitting axial motion of the shafts.

unicontrol

Fully powered controls are used in Firebird III. A short stick with a weighted knob is located between the two occupants (Fig. 9). Pushing the control forward opens the throttle while pulling back applies the brakes. Sidewise motion controls the steering.

A block diagram of the driver-Unicontrol-vehicle system is shown in Fig. 10. The driver's input forces and displacements produce command signals to electrohydraulic servos which control front wheel angle, throttle opening, and brake line pressure. The car responds in a manner determined by its geometric and inertial characteristics and the tire properties. The resulting car motions are fed back to the driver through the mass of the Unicontrol knob acting as an accelerometer.

Such a system has a number of operating advantages for the drivers. Rigid front wheel positioning is provided which makes the car path less sensitive to external wind and road disturbances. Kingpin torques resulting from road irregularities or other unsymmetric disturbances do not affect the input control since the system is irreversible. Brake actuation time is reduced since the driver has his hand on the proper control element. Car motion feedback to the driver is provided by the built-in accelerometer and is therefore not subject to change with weather conditions as is the tire aligning torque which conventionally serves this function. The mass of the control knob also revolutionizes the free control characteristics of the car by causing it to revert to a condition of zero lateral acceleration as soon as the stick is released.

A secondary control function, transmission ratio selection, is performed by rotation of the Unicontrol knob. The straight-ahead position of the winged top of the Unicontrol knob is the "drive" position, while 20 deg either side of center selects "reverse" and 80 deg either side of center, "park" position. The shape of the knob is such that these positions are readily recognized by feel, and since "reverse" and "park" can be selected by rotating in either direction, there is no confusion resulting from driving in either seat.

the GT-305 regenerative engine

An entirely new regenerative gas turbine engine, the GT-305 Whirlfire, powers the Firebird III. The GT-305 engine reaches new levels of attainment for regenerative gas turbines in horsepower per pound of fuel, horsepower per pound of engine weight, compactness, and rigidity.

The GT-302 engine used to power the Firebird I had a specific fuel consumption of 1.63 lb per hp-hr. Two years later the GT-304 in the Firebird II used only 0.77 lb of fuel per hp-hr. The principal reason for this gain was the addition of regeneration to the cycle to recover heat from the turbine exhaust. The GT-305 engine has been designed to attain a specific fuel consumption of 0.55 lb per hp-hr. Here the gain has been accomplished by improvements in all components and is the result of extensive component testing.

The design of the GT-305 engine effectively integrates the components into a clean compact unit Fig. 11). The two turbines are arranged on a common horizontal axis. Designed for an inlet temperature of 1650 F, the first stage turbine turns the radial flow compressor at 33,000 rpm through the connecting shaft. The second stage or power turbine, immediately behind the first but mechanically separate, drives the output shaft through a single stage helical reduction gear.

The power turbine develops full power at 24,000 rpm, which is reduced to 3500 rm at the output flange. A speed limiting governor permits the output shaft to turn as high as 4500 rpm to take advan-

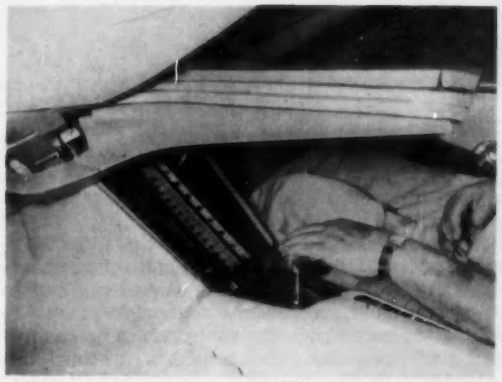


Fig. 9 — Instrument panel and Unicontrol arrangement.

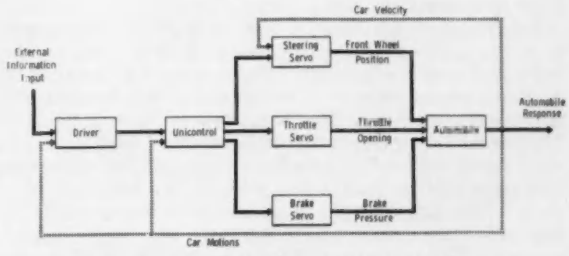


Fig. 10 — Driver-Unicontrol-vehicle block diagram.

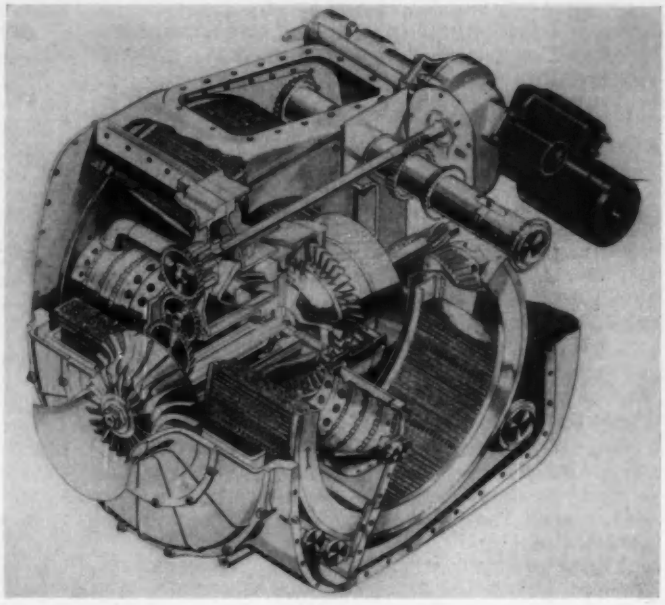


Fig. 11 — Cutaway view of GT-305 Whirlfire engine.

General Motors'

Firebird III

... continued

tage of the flat characteristic of the gas turbine horsepower curve.

The two drum-shaped regenerators are located on either side of the turbine shaft just behind the compressor casing. A bulkhead extending from top to bottom of the casing combines with side covers to form a high-pressure plenum chamber. The casings to the rear of the bulkhead form a low-pressure exhaust plenum. Each regenerator passes through the bulkhead so that about one-third of its circumference is in the high-pressure plenum and the remaining two-thirds is in the exhaust plenum. The combustors are located in the high-pressure plenum between the regenerators and the bulkhead. The turbines are located in the passage between the high and low-pressure plenums.

Compressed air discharged from the compressor into the high-pressure plenum chamber is heated as it passes radially inward through the front segments of the porous regenerator drums. The heated air then goes through the combustors where fuel is burned to bring the temperature up to 1650 F at design speed. The hot gas then expands through the turbines and is discharged within the exhaust plenum. The exhaust gas is cooled as it passes radially through the rear segments of the regenerator drums. The regenerator drums turning at about 30 rpm transfer the heat recovered from the exhaust gas to the compressed air passing through the drums in the high-pressure plenum.

The drum-type regenerators of the GT-305 engine are characteristic of the integrated engine design concept. The engine parts are arranged compactly with a straight-through air flow path and complete elimination of interconnecting ducts. This results in minimum pressure drop which is important for maximum efficiency. Another advantage of the drum-shaped regenerators is that all the hot gases and hot working parts of the engine are contained within the regenerator drums. The regenerators serve as insulating blankets keeping the heat and most of the turbine noise from reaching the outside of the engine.

Because of the engine arrangement, the size of the regenerators and the complete engine are closely related. Thus the regenerator dimensions are a compromise between large size for maximum heat transfer capacity and small size for a minimum increase in engine space. Each drum is about 22 in. in diameter and 8 in. wide. Porous material, alternating with thin metal plates, fills the space between the solid rims. Stiffening members spaced circumferentially around the drum resist the bending effects of the difference in gas pressure at the seals between the high and low-pressure segments of the drums.

The actual operating temperatures of a rotating regenerator are quite interesting. Actually there is very little periodic temperature change in any given element of the matrix. The greatest temperature difference is radially in the gas flow direction. Material at the inner surfaces of the drum is heated to about 1250 F by the passage of the exhaust gas. By the time the gas has passed through the 2 in. matrix it has been cooled to 450 F or less and the material at the outer surface is therefore only heated to about 400 F.

As the drum rotates, the heated material passes through the seal and compressed air flows through the matrix in the opposite direction to that of the exhaust gas. Entering at about 350 F, the air is heated to about 1200 F as it passes through the 2 in. of drum material. The heat capacity of the matrix is such that its temperature at any point changes only about 100 deg during each cooling and heating cycle. The temperature of the inner surface cycles between 1200 F and 1300 F as the drum rotates while the outer surface cycles between 350 F and 450 F. Thus the temperature gradient in the radial direction is large while the gradient in the circumferential direction is quite small.

The air compressor is of the radial flow type generally used in small gas turbines. The optimum pressure ratio of the regenerative gas turbine is easily satisfied by this type of compressor, and its geometry is ideally adapted to the GT-305 arrangement. The compressor discharges into the high-pressure plenum through the annular passage which completely surrounds the diffuser. An efficiency of 78% based on total to static pressure ratio is attained.

The design of the combustion system provides a desirably low pressure drop of 1.8 in. of Hg or 1.75% of the component pressure at full load. Measured combustion efficiency is 99%, and the use of air atomizing fuel nozzles results in an exhaust that is completely clean, odorless, and nontoxic.

The dry weight of the GT-305 engine including all accessories is 590 lb. The engine rating of 225 hp results in a specific weight of 2.7 lb per hp.

The only instrument displaying engine conditions to the driver is the gasifier tachometer. Warning light signals show on the instrument panel for turbine over-temperature, high oil temperature, and low oil pressure.

Proving ground tests have presented an excellent opportunity to measure the progress that has been made in reducing the fuel consumption of gas turbine powered vehicles. The Firebird I, II, and III were operated under similar conditions on the test track. The Firebird II used about one half as much fuel as the Firebird I, and the Firebird III used about one half as much as the Firebird II. Thus in cars built over a span of only 5 yr, nearly a four-fold increase in fuel mileage has been achieved.

Cost analysis of the GMT-305 engine has shown that it can be built in production quantities at a price no higher than for an equivalent high-output reciprocating engine.

general arrangement and body design

Two chief influences shaped the design of the Firebird III:

1. Newly developed components were available; among them the latest regenerative gas turbine, an electronic control system obviating the need for steering wheel or foot pedals, and an auxiliary engine to run diverse accessories.
2. The look of the car should reflect the space age; the exciting technological devices contained within should be symbolized in the outward appearance.

Interior Dimensions of Firebird III

Head room	35.5 in.
Leg room	47.4 in.
Shoulder room (individual)	23.5 in.
Seat depth (maximum)	5.0 in.

In the Firebird III the passengers sit immediately aft of the front wheels, with the turbine engine just behind them. The auxiliary engine and the major mechanically driven accessories fall forward of the passengers. This arrangement provides good weight distribution.

The construction system for the Firebird III stems from the requirements that all components must be easily accessible, repairable, changeable, and installable. Thus, a formed-section chassis frame carries all mechanical components, fuel tanks, controls, and seats. The body panels are divided into relatively small units which are easily removable. Only a few man-hours are required to completely strip the body.

The outer panels are made in plaster molds, by hand layup of woven glass cloth and polyester plastic. The interior shell is of the same material. An interesting application of reinforced plastic is the large air delivery duct from the body sides to the turbine compressor. (See headline layout). This was modeled in clay, cast in plaster, and fabricated just as were the exterior panels.

The best protection for the surface proved to be clear sprayed plastic coatings. Thus a most attractive and simple finish could be obtained by spray coating opaque metallic particles in a transparent vehicle. A newly developed acrylic lacquer system was employed with both golden and silver pigments. Under varying lighting, surprising variations in color may appear ranging from a golden tan to an iridescent platinum.

Two main conditions for easy exit have been satisfied. First, the low door cut allows the feet to be swung to the ground easily. Next, the elevated door and canopy allow the head and shoulders to follow a natural path when rising. Thus, it is possible to leave gracefully a car only 45 in. high. Entrance is also assisted by these provisions.

Laminated plastic canopies provide distortion-free 360 deg visibility with low frontal area and exceptional entry conditions. The inherent problem of the high transparency of such a canopy is, of course, the sun heat loading. A substantial reduction in the infrared input to the occupant results from a highly reflective coat of aluminum on the inside of the canopy. Vacuum-deposited on the plastic, and protected by clear lacquer, this layer of aluminum reflects 99.8% of solar radiation directly overhead and fades out gradually to the rear where some 80% of the visible spectrum is allowed to pass.

AIR temperature, humidity, and velocity are controlled to simulate weather conditions in Ethyl's three controlled-weather rooms. Equipment comprises an air blower, cooling and heating coils, humidifying water-spray nozzles, and ventilation inlets and outlets.

The blower cools the engine and drive train, and circulates room air through the rest of the air conditioning system. It also provides air to the front of the vehicle at any desired velocity up to 100 mph, and that velocity can be controlled to increase automatically with increased wheel speeds.

Cooling coils, located above a false ceiling, are part of a liquid ammonia recirculating refrigeration system. Heating coils, similarly located, are heated by steam. The humidifying nozzles, located upstream from the blower, eject water and compressed air together to produce a vaporized mist. Dehumidification is controlled by the cooling coils.

Each room has an auxiliary system for controlling room temperature to ambient, or above, by using outside air. Lacking humidity control, this system is used where humidity is no factor. For temperature control, the dampers in the air inlet and in the recirculation duct are modulated in unison to proportion the outside make-up air and recirculated air to the blower.

One of the Detroit rooms has a refrigeration capacity ample for cold starting and warmup tests of fuels at - 20 F. The system can cool the room to - 40 F. The San Bernardino room can be used for cold-starting tests at 0 F and for warmup work at temperatures above 30 F.

Air temperature in all three rooms can be controlled to 70 $\pm$2 F during fuel rating work with open throttle acceleration tests up to 100 mph. Temperatures can be provided high enough for vapor lock tests. Two rooms can be operated at 130 F, the third at 140 F.

Humidity control systems can maintain constant humidity at 50 $\pm$2 grains of water per pound of dry air at room temperature of 70 F. Humidity can be varied over a wide range of room temperatures above 50 F, depending on outside humidity.

Controlled-weather

. . . saves time and money, and findings correlate

Based on paper by

H. C. Sumner, H. A. Toulmin, and G. W. Stanke

Ethyl Corp.

IN controlled-weather rooms in laboratories, effects of fuel and engine design are often found which otherwise would be hidden by weather variables.

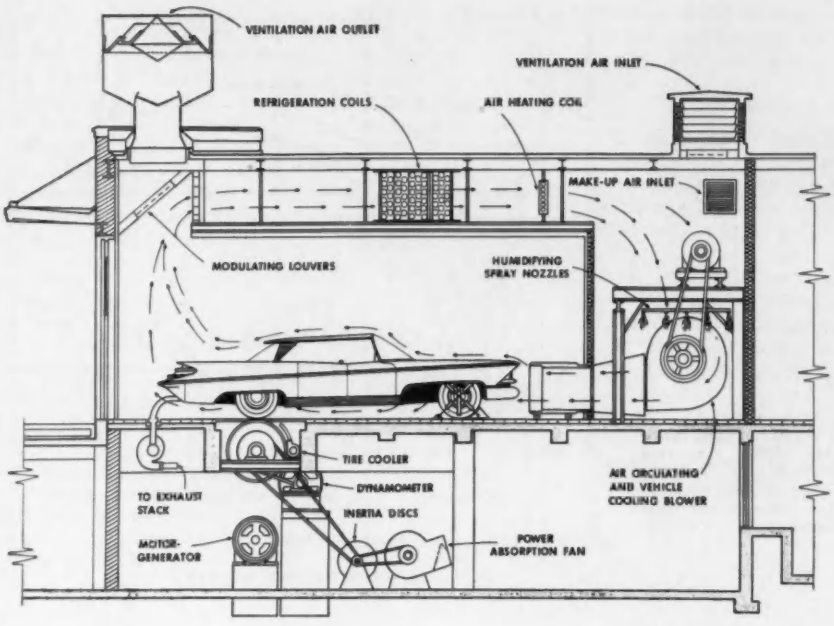
Such rooms are particularly well suited for determining the octane number requirement of engines and the octane rating of fuels in vehicles. The tremendous number of fuel knock ratings and determinations of octane requirement needed for such studies could not possibly be accomplished on the highway with the attendant delays of weather and traffic, and with the disadvantages of testing moving vehicles away from home base. Moreover, control of temperature and humidity greatly improves the reproducibility of data, thereby reducing the work required for a given evaluation.

This advantage of reproducibility can be illustrated by a test conducted to show the effect of ambient temperature on primary-reference-fuel octane number and on the ratings of eight different commercial fuels. Here, absolute humidity was held constant at 30 grains to isolate temperature effects during test. The octane-number requirement increased only about 0.5 unit with a 55 deg rise in ambient temperature. For the same temperature increase, however, the ratings of the commercial fuels at 2500 rpm decreased an average of about 2 octane numbers. These changes in engine requirement and fuel ratings reflect the changes in carburetor air and coolant temperatures.

When tests were run to determine the effect of humidity on primary-reference-fuel octane number and the ratings of these same eight fuels (with temperature constant at 90 F), the octane-number requirement was found to decrease about 1 octane number for an increase of 90 grains in humidity. At the same time, fuel ratings increased by about 1 octane number for the same increase in humidity.

significance of data

The weather effects revealed by the aforementioned data are large enough to upset comparisons



Controlled-weather chassis dynamometer gives test results that correlate well with road tests conducted under the same climactic conditions.

room testing

well with road test data.

of fuel or engine design. Also, octane-number requirements in terms of commercial fuels can be affected much more than indicated by requirements in terms of primary reference fuels. For example, a rise in ambient air temperature of 55 deg increased primary-reference-fuel requirement by only 0.5 unit, but decreased commercial fuel ratings by 2 octane numbers at 2500 rpm. The commercial fuel requirement, therefore, increased by about 2.5 octane numbers at this speed. Likewise, a decrease in humidity of 90 grains increased commercial fuel requirement by 2 octane numbers instead of the 1 octane number for primary reference fuels because of the decrease in commercial fuel rating.

Weather control has proved invaluable in investigating the effects of combustion-chamber deposits on octane number requirements. Useful comparisons of the effects of additives must sometimes show differences of a fraction of an octane number. To find significant differences in octane-number requirement of less than 1 octane number with 90% confidence requires a tremendous amount of testing. At our San Bernardino laboratory, a significant difference of 0.6 octane number requires 27 tests on nine vehicles operating a total of 220,000 miles. If control of temperature and humidity were eliminated from the controlled-weather rooms during test, the test mileage, hence the cost, would increase by an estimated 30–40%.

laboratory and road test correlation

Excellent correlation exists between octane-number requirements and fuel ratings obtained on the road and in the controlled-weather rooms. A test program on two vehicles and 27 fuels for a total of 291 determinations showed:

1. Octane-number requirements in the controlled-weather room were within 1 octane number of road data at all engine speeds.

2. About 95% of road and controlled-weather room fuel ratings differed less than 1 octane number. Maximum difference for any one fuel was 2 octane numbers.

3. The repeatability of fuel ratings was about the same for both test locations and both cars, as indicated by standard deviations of about 0.5 octane number.

rumble and knocking surface ignition

The value of controlling weather during investigation of rumble was made very evident by highway tests conducted at San Bernardino in winter. It was found that the tendency to rumble increased with increases in ambient temperature. The vehicles did not rumble at ambient temperatures below 40 F, but rumbled during 46% of the observations in the 71–80 F temperature range. While humidity and barometric pressure may have affected data to a

Controlled-weather room testing

... continued

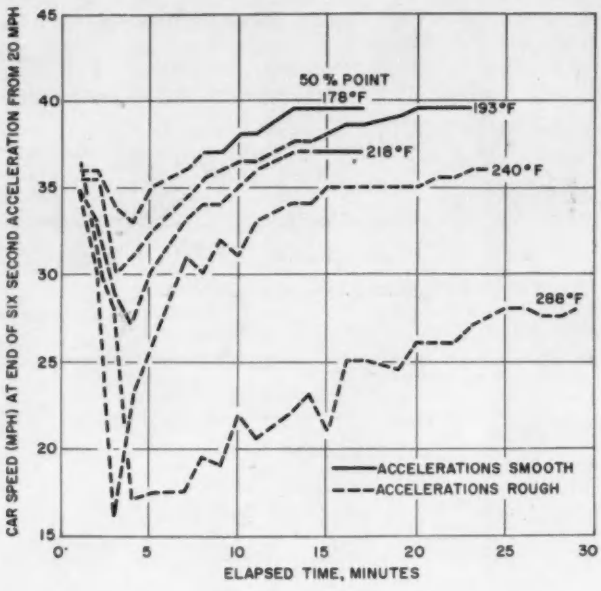


Fig. 1 — Tests of fuels having different 50% evaporated temperatures show the definite effect of that temperature on warmup and final performances.

degree, the smoothness of the curve of plotted data leads to the belief that the temperature effect was predominant. Only carburetor air temperatures varied greatly with changes in ambient temperature; jacket water temperatures did not change significantly since thermostats were controlling during all accelerations.

Uncontrolled weather can play havoc with evaluations of fuel or oil additives designed to reduce rumble. At San Bernardino two test programs were run, one in summer, the other in winter, and as part of the test, vehicles were accelerated up a 7% grade. Although test procedures were identical, considerably less rumble was experienced on the 7% grade in winter. On the other hand, rumble observations in the controlled-weather rooms were similar during both programs.

Studies of knocking surface ignition also require weather control. In one test the surface ignition requirement of a vehicle was reduced from 97.5 to 90 octane number when the temperature was lowered from 90 to 35 F. The vehicle was surface ignition limited at 90 F, but knock limited at 35 F. The difference in surface ignition requirement due to temperature alone was as large as the effect of a commercial dosage of the best phosphorous ignition-controlled compound.

Table 1 — Repeatability of Vapor Lock Tests

(Values given are for Reid vapor pressure, psi; with 95% confidence limits)

	Car A	Car B
Road and Controlled-Weather Room	±0.9	±1.0
Controlled-Weather Room	±0.6	±0.7

cold starting and warmup tests

The cold starting performance of an engine or a fuel can be studied in the controlled-weather room by using a complete automobile or a bare engine mounted on a skid. Such a room insures uniform ambient temperatures from test to test, and permits low-temperature operation throughout the year.

Warmup tests are conducted by setting the chassis dynamometer inertia and fan loading to duplicate road-load conditions and level-road acceleration for the particular car to be tested. The eddy current dynamometer is used only for light braking to return the vehicle to road-load speed after completing the acceleration. The wind speed is set to match the rear wheel speed of the vehicle automatically. When this is done, underhood and engine temperatures correlate closely with results obtained on the road. Hence the automatic choke operation and rate of engine warmup also correlate well.

To study the effects of fuel volatility on warmup performance, a simple cycle has been found to give good correlation with customer evaluations. The car is run at 20 mph, road-load, and its performance is measured at the end of each minute of operation until fully warmed up. The measure of performance is based on the speed obtained at the end of a 6-sec, detent-throttle acceleration, starting from 20 mph. Following each acceleration, the car speed is returned to 20 mph by mild braking with the eddy current dynamometer. This cycle is repeated at 1-min intervals until three successive accelerations

indicate the vehicle is fully warmed up. Any evidence of rough operation, flat spots, or backfiring of the engine is noted. Readings of the fuel burette are taken at idle after the initial start and at idle at the end of each five cycles. Fuel economy during warmup is computed from these measurements.

The results of tests at 0 F on a series of fuels having different 50% evaporated temperatures are shown in Fig. 1. The effect of the 50% evaporated temperature on warmup and final performance is evident. With this test it is easy to separate two fuels whose ASTM distillation curves are displaced by 5 deg.

carburetor icing

The effect of temperature and humidity on carburetor icing is shown in Figs. 2 and 3. These data indicate that reproducibility in tests is impossible without careful control of both temperature and humidity. They indicate also that the most critical condition is 40 F and 100% relative humidity. Weather studies show this condition to occur only a small percentage of the time, even in areas where icing is most prevalent. For this reason, most of our tests have used 40 F and 85% relative humidity as being more representative.

vapor lock testing

In one vapor lock test program, two cars were tested on the road, then run on the same test cycle in a controlled-weather room. The repeatability in the controlled-weather room was better than that obtained on the road, as shown in Table 1.

There was no significant difference between the vapor lock tolerance of a car when tested on the road or on the chassis dynamometer. The maximum Reid vapor pressure difference between the iso-vapor lock lines for the road and the chassis dynamometer was 0.3 psi.

Outdoor vapor-lock testing is usually limited to 5–6 hr in a day, even in the Southwest, hence no more than three runs per day can be made. In a controlled-weather room such testing can be carried on around the clock to achieve 12 runs per day.

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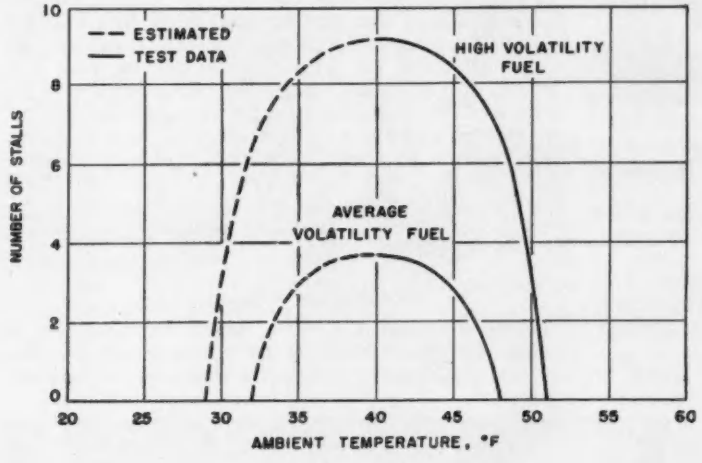

Fig. 2 — Controlled-weather room tests show 40 F and 100% relative humidity to be the most critical condition for carburetor icing.

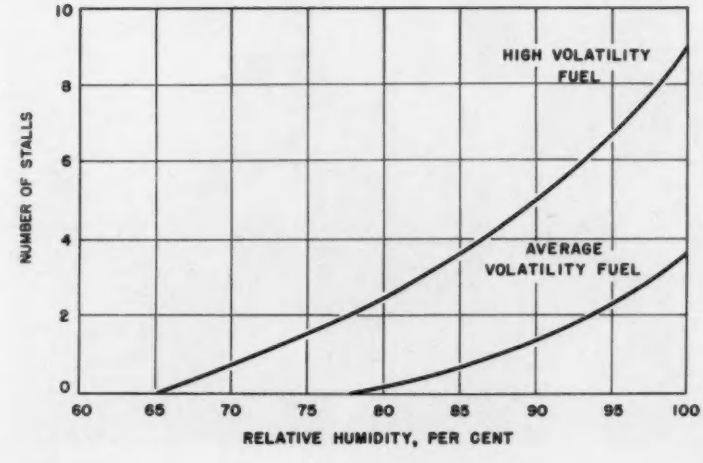

Fig. 3 — While a temperature of 40 F and relative humidity of 100% are most critical, a relative humidity of 100% is uncommon even where carburetor icing is prevalent. Tests are now run at 40 F and 85% relative humidity because these conditions are more representative.

Highway Research

Based on paper by

W. B. McKendrick, Jr. and W. J. Schmidt

AASHO Road Test

THE AASHO Road Test — the most comprehensive study of its kind ever tackled — has five objectives. These are:

1. To determine the significant relationships between the number of repetitions of specified axle loads of different magnitude and arrangement and the performance of different types and constructions of pavement.
2. To determine what specified axle loads and gross vehicle loads do to bridges of different design and construction.
3. To study such subjects as paved shoulders, base types, pavement fatigue, tire size and pressures and correlate the findings with the results of the basic research.
4. To provide a record of the type and amount of effort and materials required to maintain pavements.
5. To develop instrumentation, procedures, and data useful for the future as well as for evaluating existing highways, and pointing the path to further promising research.

Significant and performance are the key words in the first objective. Significant is used in the mathematical sense. The significant relationship is one in which the effects on one variable are known to be caused by the other variables with a specific degree of certainty.

An important feature of the design of the experiment is the use of the complete factorial in which each design factor level occurs in combination with all other design factor levels. This makes it possible to estimate the effects of design factors and their interactions independently of one another.

Two other important features are randomization in the layout of the experimental units, and replication, or repeating of experimental units, at least on a limited basis. In the random layout, any test section had an equal chance of being anywhere on its respective loop tangent, and the loops themselves are located along the right-of-way in random order. This is done to shake loose the effects of the design factors from the effects of error variables. Replication provides the means for measuring experimental error so that the reliability of results can be appraised.

Interpretation of Performance

While performance must always be a matter of human judgment, there is a method of utilizing the collective judgment of a group of persons to validate

Fig. 1 — This device uses nuclear energy to test the density of crushed stone base course material after it has been set in place.

Seeks End of Guesswork

indices derived from objective measurements. Use will be made of a performance rating panel composed of 13 men with highway engineering background.

Deriving a performance index for any test section begins with the panel-making individual "present serviceability" ratings of selected test sections. The mean present serviceability rating of the panel is then used to validate an index made up of a weighted sum of terms involving measurable elements of pavement behavior such as roughness, cracking, faulting, and the like. When an appropriate summation of these elements is obtained, the present serviceability ratings of any test section can then be determined without an actual panel rating. But there will be periodic panel ratings for checking validity of indices.

Present serviceability ratings can be plotted against number of load applications or against time. This plot will represent the performance of a test section. The panel is then called upon to make a performance rating after examining the plot of present serviceability against time. The performance index is then derived in the same manner as the present serviceability index.

Still another index will be developed to predict the condition of a highway at some future date if it is to be subjected to known loading and environment. Some elements in this index may be identical with those in the present serviceability index, but it is likely to include such measurements as strains and deflections.

Use of Instrumentation

Several interesting pieces of test equipment are being put to use in the program which will test asphaltic concrete pavement, and both reinforced and plain portland cement concrete, with a fleet of 70 vehicles ranging from pickups to large tractor and semitrailer combinations. One piece of equipment, designed and built by the staff, will dry a sample of material in 23 min as opposed to several hours in a conventional oven. Another item is a device which uses nuclear energy to determine the density of materials. It is based on the fact that the attenuation of gamma radiation increases with increases in density. It is employed to determine in-place density of the crushed stone base course material (Fig. 1).

The most novel instruments are those used to measure surface deformation. Among these is an automatic model of the "Benkelman Beam." It is designed to measure and record surface deflections in flexible pavement near the rear wheels of a loaded trailer. Its seven probe arms measure 11 deflections automatically at regular intervals while the vehicle moves at 3 mph and the data are recorded on equipment carried on the trailer.

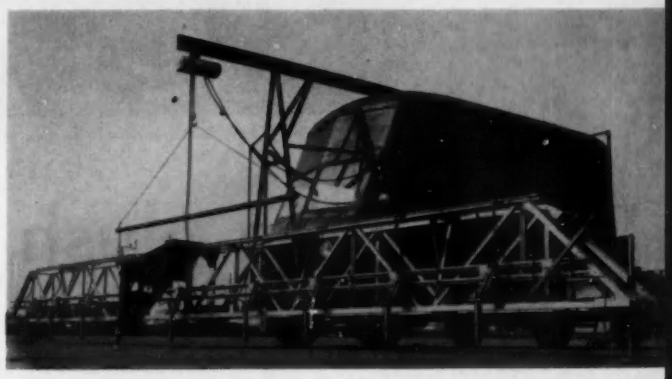

Fig. 2 — Nine-point profile or rut depth in flexible pavement can be obtained with this transverse profilometer, which comprises nine pneumatically operated probes supported by a truss. Van equipment automatically averages the readings from the two outer probes (when probes are used in groups of three) and subtracts this average from the reading of the center probe to give direct rut depth.

There is a transverse profilometer, consisting of a truss supporting nine pneumatically operated probes. It can provide a nine-point profile, or read the rut depth in flexible pavements when probes are used in groups of three (Fig. 2).

One of the most difficult instruments to develop was a longitudinal profilometer. This very important device measures and records, on oscillograph tape, the slope of the pavement in the wheel paths of the test vehicles. It operates as a trailer is towed along the roadway at about 7 to 8 mph. During the two-year test period it is expected to produce an actual 42 miles of oscillograph tape. Turning this analog record into digital form entails reading the tape at intervals of about seven per inch, a task which employs an automatic chart reader. The digitized information is punched into paper tape, which can be run directly into the computer for analysis.

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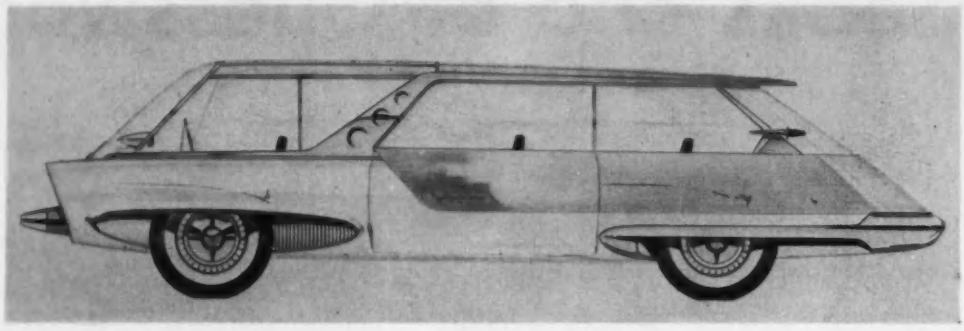
Stylist's idea of the multipurpose body of tomorrow.



from plush pullmans to pint

multipurpose bodies are on the up . . . in numbers and in

Excerpts from paper by

Walter O. Koehler,
MOTOR Magazine

THE ever-increasing popularity of the multipurpose body is one of the most significant trends in automotive design since World War II.

Both here and abroad, manufacturers have introduced a wide assortment of vehicles. They range from pickup trucks with passenger-car styling and comfort to compact buses with sleeping accommodations and virtually all of the other comforts of home. The most familiar multipurpose body type — the station wagon — accounted for 14.5% of all new car sales in 1957, compared with 9.6% in 1955. One manufacturer in 1957 reported 28% of his total production was station wagons. One station wagon model outsold all other body styles in the line.

It's easier to explain what a multipurpose body does than to define what it is. For the farmer it provides the comfort of a passenger car for as many as six people, combined with the hauling ability of a light pickup truck. For the sportsman it gives storage space for hunting, fishing, or boating equipment and living quarters at the campsite. For the car or truck manufacturer it's an economical means of widening potential markets and utilizing existing tooling to maximum advantage.

A look at typical examples of current multipurpose bodies gives a basis for determining why they're built as they are and for some predictions about their future.

Future of Multipurpose Bodies

What is the future of the multipurpose body?

From all indications, it's a bright one. People are spending more time in their cars. The expanded federal highway system should encourage more travel by private automobile. Federal and state governments have opened new parks and other recreational facilities. We now have drive-in movies, banks, and even churches. We're practically living in our automobiles now, so there's every reason to believe that a multipurpose body which provides sleeping accommodations and other facilities will find a ready-made market. When it's not being used for vacation trips, the versatile vehicle of tomorrow will serve as a small bus for hauling the Cub Scouts or a roomy cargo carrier for garden supplies or materials for do-it-yourself projects. The vehicle manufacturer, of course, will use the same body shell for light panel and pickup trucks.

A forward-control design appears to be the logical choice for this type of vehicle, because it offers the maximum amount of usable space within given exterior dimensions. Front-wheel drive, rear or underfloor powerplants and cab-over-engine designs all present engineering problems in noise, roadability, and cost that are beyond the scope of this paper. There's no reason to believe that these problems can't be solved, however.

To the stylist, the forward control body is both a challenge and an opportunity. It's a challenge to take a shape that resembles a box and make it look like anything but a box. It's reasonably sure that fins aren't the answer. At the same time, there's opportunity for fresh, new treatments. If form wins out over function, a body of this type won't be successful, so the "longer-and-lower" school of styling will have to be restrained.

The vehicle shown above is a stylist's idea of the multipurpose body of tomorrow. Designed by Kaiser Aluminum, it would be powered by a pancake engine under the driver's seat. Front-wheel drive would make possible a low, flat floor. The wheelbase would be 112 in.

If the automobile industry is to maintain its dominant position in our economy, it must be alert to changes in our living habits and be ready to meet those changes with new

Willys Mechanical Mule, which is the simplest of all multipurpose bodies. This platform on four wheels can carry more than its own weight in cargo or passengers. It can also be used as a mobile platform for a 106-mm recoilless rifle. Its movable steering column allows it to be operated in normal driving position or by a soldier walking or crawling in front, alongside or behind the vehicle.

sized pickups

versatility—at home and abroad.

products. Suburban living, multiple car ownership, and more leisure time are creating a demand for the multipurpose body. Rising manufacturing costs make it imperative that the automotive manufacturer get the greatest possible mileage out of his tooling.

All of these factors point to a healthy future for the multipurpose body.

To Order Paper No. 35R . . .
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Multipurpose body created by the use of accessory equipment. A rudimentary shelter for driver and passenger has been added to the basic Jeep body. An extension attached to the rear of the body increases cargo space and acts as a platform for special equipment.

How the same basic body shell can be used for a panel truck and a station wagon, reducing manufacturing cost and parts inventory. The roof, lower quarter panel, and front doors are identical on both bodies. On the station wagon, the upper rear quarter panel has been replaced by glass and reinforced by an additional pillar. Lift gate and tail gate take the place of the side-hinged doors of the panel truck. With only minor modifications, the same body is used for a small ambulance.

(more on following pages)

Ford Ranchero is a symbol of our changing times. Today, however, the farmer and his wife share with their city cousins a growing interest in styling and comfort. The Ranchero retains the cargo capacity of a ½-ton pickup, while providing the ride, styling, and comfort of a sedan or station wagon. Rear quarter panels from the 2-door station wagon form the sides of the pickup body. Doors and front-end sheet metal are standard passenger-car stampings.

Chevrolet El Camino uses passenger-car panels in front and modified station wagon quarter panels for the outer walls of the pickup box.

International Harvester Travelette. The 6-passenger cab has three doors, one at each side for the front seat and a third at the curb side for the rear seat. The cab and a 6-ft pickup body are mounted on a wheelbase of 129 in. Overall length is less than 210 in., approximately the same as that of the most popular passenger cars. The Travelette is one of a family of vehicles, all built around the standard panel truck body. Provision is made in the outer panel of the body for the third door.

International Metro-Mite is an example of the forward-control delivery truck. Because of the large amount of unobstructed space, this body is easily fitted with seats for use as a small bus. The jitneys of Atlantic City are probably the best known examples of this type of conversion. The Metro-Mite is a local delivery truck with a wheelbase of only 96 in. and overall length of 159 in. The body is of unitized construction.

One of the most compact vehicles built anywhere is the Fiat Multipla, which measures only 140¾ in. overall. It has a wheelbase of 79 in., is 62¼ in. high and 57 in. wide. Two interior arrangements are available.

In one version, a bench-type front seat is provided for the driver and one passenger. Behind this seat, four individual seats, in rows of two, make it possible to accommodate a total of six passengers. The four rear seats can be folded down into the floor to form a cargo platform of about 19 sq ft. The alternate interior arrangement consists of two bench seats, giving a passenger capacity of four or five, depending on the size of the passengers and how well they know each other. The rear seat cushion is pivoted at the front, while the rear seat back is hinged at its lower edge. The cushion swings forward to a vertical position immediately behind the front seat, allowing the back to move forward to form a flat floor. The seats can also be converted into a bed. When the latches are released, both seat backs swing backward into a horizontal position. The secret of the Multipla's roominess is its compact rear-mounted engine. Since the powerplant, transmission, and differential are all located at one end, there's no driveshaft to intrude upon passenger space. Integral body construction avoids bulky frame members.

Volkswagen Micro Bus provides maximum interchangeability of body panels in its two versions and permits a wide variety of models with minimum tooling. All have a wheelbase of 94.5 in. and, with the exception of the Micro Bus De Luxe, an overall length of 165 in. Net weights for the Volkswagen Transportation line — of which the Micro Bus is a part — range from 2094 lb for the pickup to 2392 for the Micro Bus. With minor variations, all models are approximately 68 in. high and 76 in. wide.

Tempo Matador, a somewhat larger vehicle than the Volkswagen, also has engine, transmission, and differential mounted at one end of the chassis. In this case, however, the designers chose the front end. This cab-forward, front-wheel drive vehicle has the advantage of a low, flat floor and unobstructed rear loading doors. The 14-passenger bus shown here has a wheelbase of 110 in. and an overall length of only 185 in. A Tempo Matador panel delivery truck with large side and rear loading doors utilizes most of the same panels. Still another application of the same basic body is a double cab mounted on a long-wheelbase pickup truck. Because of its front-wheel drive and a simple tubular frame, the Matador is easily adaptable to bodies of various lengths.

(more on following page)

from plush pullmans

to pint-sized pickups

. . . continued

English Ford Thames 800 series is also of the forward control type. These vehicles follow conventional American practice in the location of their mechanical components, with front-mounted engine and rear-wheel drive. The diminutive bus shown here seats eight people and has luggage space at the rear. Two additional folding seats can be provided in the area behind the rear bench seat.

When the large side door is opened, a step folds down for easy entry. Looking at the Thames bus, it's hard to believe that its wheelbase is 10½ in. shorter than that of a Volkswagen passenger car and that it measures a mere 159 in. overall.

The Thames 800 panel truck is virtually identical in outward appearance to the bus except for recessed panels instead of windows in the side loading door and upper panel area. A two-man cab, furnished with either a chassis or a pickup body, uses front-end sheet metal and a special back panel. The pickup body employs the same lower side panels as the panel truck and bus.

Ford Squire is typical of foreign station-wagon design. The conventional wagons, mounted on passenger-car chassis, resemble scaled-down American models and reveal little that's original or new. Foreign manufacturers, however, have managed to cut the station wagon down to a surprisingly small package.

Rotary Valve Gives Fast

It has fewer parts, is lighter in

Based on paper by

Philip B. Zeigler

Saginaw Steering Gear Division,
General Motors Corp.

SAGINAW has developed a rotary valve gear that provides an instantaneous hydraulic response. It is lighter and smaller than the previous gear and it has fewer seals and components.

A cutaway view of this rotary valve gear is shown in Fig. 1. The valve is located at the extreme left. A ball nut and worm are shown at the center, and the pitman shaft extends out at the bottom.

In designing this gear the conclusion was reached that to obtain instantaneous valve response the valve must be the first element under the handwheel and be directly connected so that the rotary motion of the wheel would actuate the rotary motion of the valve directly. The "sensitivity" effect gained can be calculated by measuring the pressure buildup in the steering gear as a function of steering windup, with the steering gear output shaft locked. Pressure starts to build up at about 0.025-deg rotation of the handwheel, and builds up to 1000 psi at approximately 2-deg rotation of the wheel. This is in sharp contrast with the previous gear, which started to build up pressure at about 2-deg rotation and required 8-deg rotation before pressure reached 1000 psi.

One of the greatest problems in design was to absorb the road shock fed back from the heavy unsprung mass of the front wheels. These forces are

Gear Power Steering Response

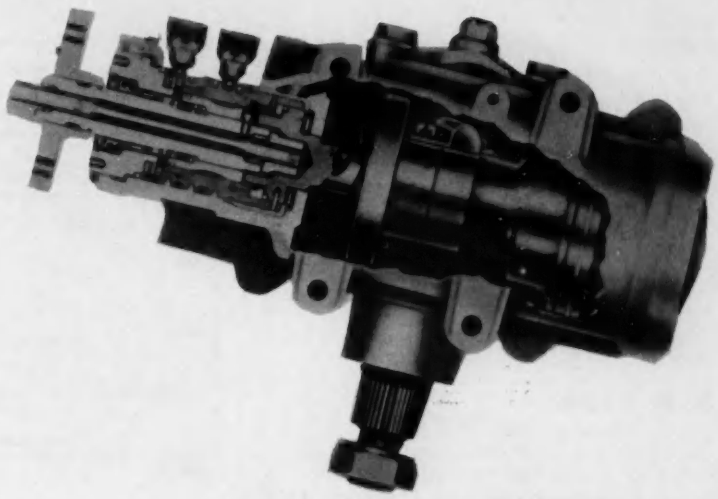


Fig. 1 — Cross-section of Saginaw rotary valve gear. Valve is at extreme left. Handwheel is connected to valve by small torsion bar, which deflects to produce rotary motion for valve actuation.

weight, and smaller in size.

particularly violent when they are set up on washboard roads at critical speeds, which excite the natural frequency of the front end. With a slow-acting valve dampened by high friction, this was a minor design problem. With a valve having instantaneous response, and the negligible internal friction, the problem became serious. It was solved by valve port configuration and by the addition of a poppet valve to lock up the hydraulics during severe feedback. Fig. 2 shows the pick-up pressure values before and after improvement.

New Features in Design

The ball bearing screw has been designed with a curved pitch line. This is assembled selectively so that there is always a preload between the ball nut and screw on center. Seals have been reduced from 18 to 9 in number. This was accomplished by designing the steering gear housing to receive all of the working parts in a concentric design. The sealing needed for an externally attached valve and all of its related components is, thereby, eliminated.

The rack piston and ball nut are made in one piece instead of two, which does away with a minor but irritating service problem. A wear washer on the pitman shaft has been designed to make the gear self-adjusting with miles, so that under normal usage the gear should be adjusted permanently for the life of the vehicle.

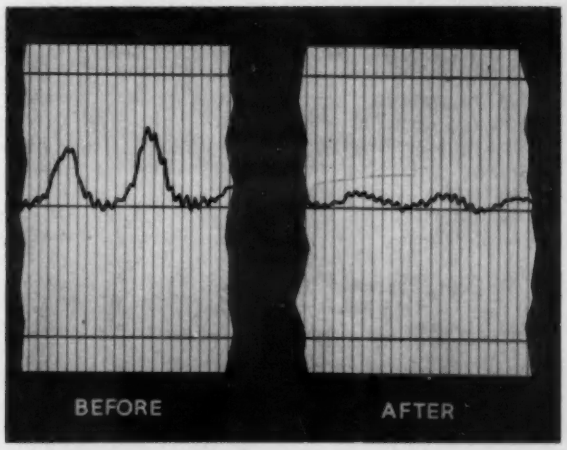


Fig. 2 — Pickup pressure values within gear before and after altering valve port configuration and adding a poppet valve to lock up hydraulics during severe feedback.

To Order Paper No. 195 . . .
. . . on which this article is based, turn to page 6.

ACID CONDENSATE Effect on

- **Acceptable controls are available now; better methods are still sought.**

Based on paper by

R. A. Heath

Michigan Division, Walker Mfg. Co.

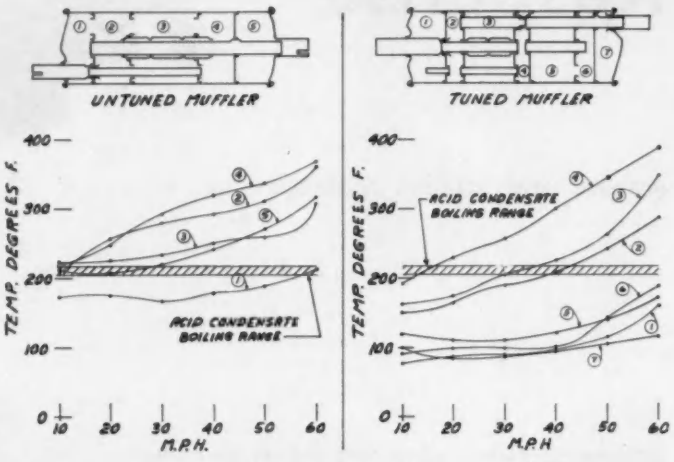
ACID CONDENSATE and its effect on mufflers is being controlled to an acceptable limit by a combination of three means:

- **Use of hot dipped zinc**
- **Use of aluminized steel.**
- **Improved design.**

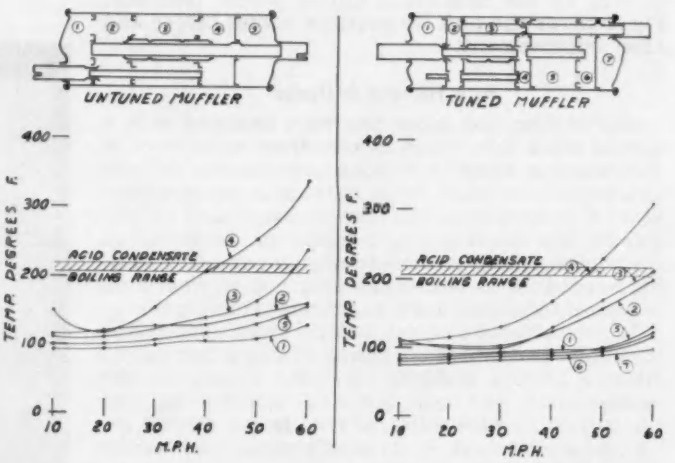
But, at the present time, some 39 different metals, coatings, and alloys are still being tested toward the end of still better metals to improve muffler life even further. Stainless steel, while good for mufflers, is hard to form and weld, besides being relatively high in price.

The illustrations at the right show specifically some of the conditions of service and environment which illustrate the need for controlling acid condensate . . . and the need for the continued search for still better methods of control.

To Order Paper No. 38U . . .
. . . on which this article is based, see p. 6.



Comparison of shell temperatures on the "hot side" of two current basic muffler designs (dual system). (The "hot side" takes most of the exhaust gas during city driving.) These "hot side" temperatures run as much as 100 F cooler than corresponding temperatures for the same designs on single exhaust systems. (Mufflers tested on same car.)



Comparison of shell temperatures on "cold side" of same mufflers as shown above. Neither design is sufficiently warm to drive off the condensate which boils at around 202–210 F. (The "cold side" is caused by a heat valve, which forces most of the exhaust gas over the engine and under the carburetor.)

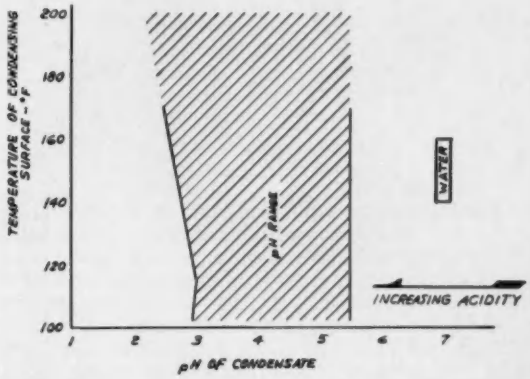
Mufflers Controllable

Acid Content of Typical Exhaust Gas Condensate — Based on Its Chemical Analysis

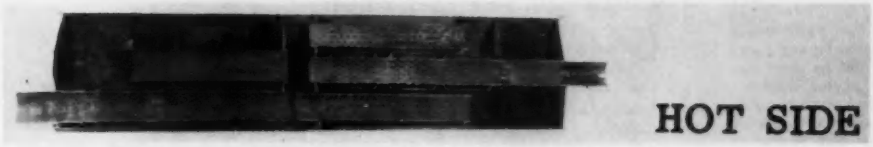
Chemical Formula	Common Name of Acid	Concentration, mg/l
HCl	Hydrochloric	580
H_2SO_4	Sulfuric	141
H_2SO_3	Sulfurous	17.5
HBr	Hydrobromic	35.5
H_3PO_4	Ortho Phosphoric	5.2
H_2CO_3	Carbonic	423

In addition to the above the condensate had suspended solids of 256

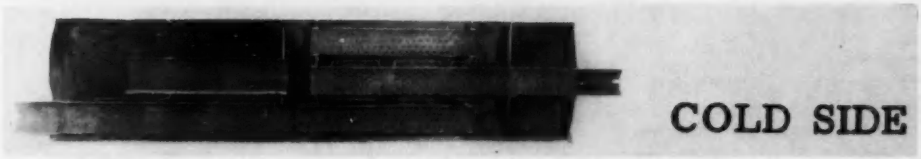
Composition and relative parts by weight of acids in a typical sample of exhaust gas condensate. (There is no evidence to prove that today's fuels are any more acid than those of 10 years ago.)



Range of pH readings — which define acidity in terms of the hydrogen ion — found in various condensates from road and laboratory tests.

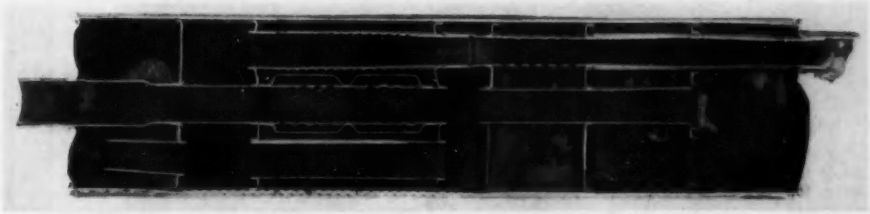


Both sides of the dual exhaust are in excellent condition after 19 months and 19,669 miles of service.



Mufflers protected with hot dipped zinc and aluminized steel parts, and a drainage system.

"Hot" and "cold" sides of a dual muffler system which gives satisfactory life using properly coated steels and a drainage system. When carefully engineered, drainage of condensate to hotter sections can give considerable benefit.



Dual muffler embodying extended use of hot-dipped zinc and aluminized steel parts . . . and a modified drainage system. After 18 months (19,653 miles) of service, this muffler was in good condition when removed and had many months of life left in it.

How to Choose the

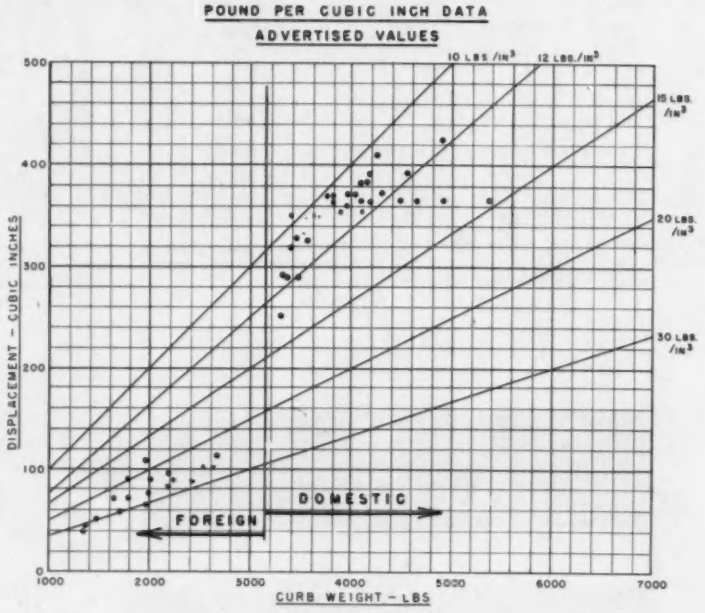


Fig. 1 — Difference in performance standards between domestic and European cars is brought out by the range of weight/cu in. of engine displacement values for the two markets. Advancements in efficiency are expected to bring the domestic cars to the 15 lb/cu in. line without lowering the performance.

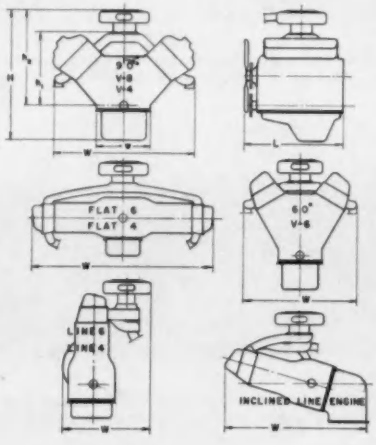


Fig. 2 — Major disadvantage of flat engines is their inability to fit in the front end of a modern car. Either the engine design has to be compromised or else positioned so high that the tunnel in the car is further elevated and the center of gravity raised.

OHV ENGINES		REPRESENTATIVE DIMENSIONS					
		HEIGHT			WIDTH		LENGTH
		OVERALL H	℄ CRANK TO CAM FLANGE h_1	℄ CRANK TO AIR CLEANER h_2	OVERALL W	AT MANIFOLD W	FRONT OF FAN TO REAR OF FLY-WHEEL L
V-8	381 CU. IN. 4.12 X 3.50 (REFERENCE)	31.0	13.3	22.5	26.3	11.0	30.5
V-6	231 CU. IN. 4.00 X 3.06	31.9	14.2	23.4	23.0	11.0	28.0
FLAT 6	231 CU. IN. 4.00 X 3.06	25.0	7.3	16.5	31.0	—	27.0
INLINE 6	231 CU. IN. 3.44 X 4.16	32.1	14.4	23.6	24.0	11.0	32.8
INCLINED INLINE 6	231 CU. IN. 3.44 X 4.16	28.7	11.0	20.2	24.0	—	31.8
V-4	120 CU. IN. 3.56 X 3.00	30.5	12.8	22.0	25.0	11.0	21.0
FLAT 4	120 CU. IN. 3.56 X 3.00	24.9	7.2	16.4	30.8	—	21.5
INLINE 4	120 CU. IN. 3.44 X 3.25	30.7	13.0	22.2	24.0	11.0	24.7
INCLINED INLINE 4	120 CU. IN. 3.44 X 3.25	27.5	10.0	19.0	21.5	—	23.7

Abridgment of an
SAE Detroit Section Paper

Engines for Future Cars

Based on paper by

Robert A. Dent
Chrysler Institute of Engineering

• As the weight and performance of future cars change, so will the type of engine used. The choice of engines will depend in large part on the space available and the riding qualities desired.

CHANGES in the size and shape of tomorrow's cars will again open the question: Should the engine be flat, in-line, or V; mounted in the front or rear; and have four, six, or eight cylinders? The answer will come in two parts. First, the size and weight of the car and its expected performance will narrow engine selection. And second, the inherent characteristics of each engine combination will pinpoint the proper design.

Car Weight Is Key to Displacement

Using the performance standards of this country, a displacement of one cubic inch for each 10–15 lb of car weight is required. Current European cars carry 20–30 lb per cu in. Fig. 1 shows this relationship for high production domestic and foreign cars.

As the displacement goes up, so does the number of cylinders. Engine efficiency, producibility, and reliability have determined the cross-over points approximately as:

- Four cylinders for under 120 cu in. displacement.
- Six cylinders for 120–250 cu in. displacement.
- Eight cylinders for above 250 cu in. displacement.

This results in two "break points" in car weight at 1700 and 3500 lb. The assumption is that future American cars will come closer to the 15 lb/cu in. line in Fig. 1 as improvements are made and performance standards are kept constant.

Locating the engine in the front or rear of the car is also determined in part by car weight. As the engine weight increases in relation to the gross vehicle weight, its effect on stability and control becomes more pronounced. Also, as the vehicle weight gets large compared to passenger weight, the engine plays a larger part in car stability and control. These two effects have led to a rear engine car when engines are small and passenger weight is a major weight item. The consensus of opinion of car designers is to avoid heavy engines in the rear. At present, 90% of European production makes use of the front engine location, and most of the remaining rear engine cars have a displacement of under 75 cu in.

Space Limits Engine Selection

Fig. 2 tabulates the critical dimensions of V, flat, and in-line engines of 4-, 6-, and 8-cyl engines. These dimensions are for conventional designs where good thermal efficiency is maintained and overhead valves are used. Immediately apparent is the width of the flat 4's and 6's. As long as cars are steered by the front wheels, it will be difficult to fit a 31-in. engine into the less-than-30 in. space between longitudinals or control arm pivots. Two ways of fitting the flat engines in the present space would be:

1. Sacrifice thermal efficiency and go to a very short stroke (less than three inches).

2. Return to L-head valve gear.

Length limits the in-line engines. Eight-cylinder engines are not even in the running and the sixes are held to a 250 cu in. displacement. Sixes now use a longer stroke than bore to shorten up the engine. This gives good thermal efficiency but limits power because of limited valve size.

Some relief on the length problem can be obtained by designing the water pump on the side of the block

How to Choose the Engines for Future Cars

. . . continued

and using an offset fan and radiator. Also, the engine can be leaned over at an angle similar to the Meyer-Drake racing car adaptations. This approach reduces the height of the engine.

One way of retaining the length adventage of the flat engine but eliminating its width disadvantage is to use the V configuration. Bank angles of 120, 90, and 60 deg can be used. This has been the solution on 8-cyl engines. However, on sixes there is a less decided advantage of the V over the in-line design. Part of this advantage is in the dynamics of the engine motion.

Balance through Design

The reciprocating and rotating parts of an engine produce inertia forces and couples that are potential sources of engine vibration or "roughness." Sometimes it is possible to design the engine in such a way that the forces and couples of the different parts just balance each other out and the net effect on the engine as a whole is zero. In other cases, the smaller forces can be taken care of by proper engine mount design, and lastly is the condition where the effects are too severe for passenger-car use.

These inertia forces act periodically with the largest forces occurring at the same frequency as the speed of the crankshaft (first harmonic). The next significant force occurs at twice the crankshaft speed (second harmonic) and so on. The size or magnitude of the force decreases as higher harmonics are examined. This is why, for practical purposes, only the second harmonic of the forces and couples is considered. Above this, the magnitude of the unbalance is small enough to be handled by normal mounting design.

Fig. 3 gives a summary of the primary (first harmonic) forces and couples as well as the secondary (second harmonic) forces and couples that occur in different configurations of 4- and 6-cyl engines. It follows that the in-line and horizontal sixes enjoy an inherent advantage in engine balance.

When using a design that has an unbalanced force, size and speed limitations will result. For example, the 4-cyl in-line engine has an unbalance secondary force equal to four times the force of one cylinder. With a 2-lb reciprocating weight per cylinder, an R/L ratio of 0.3, and a stroke of 3.5, the engine will have:

- A 30-lb unbalance force at 500 rpm.
- A 3000-lb unbalance force at 5000 rpm.

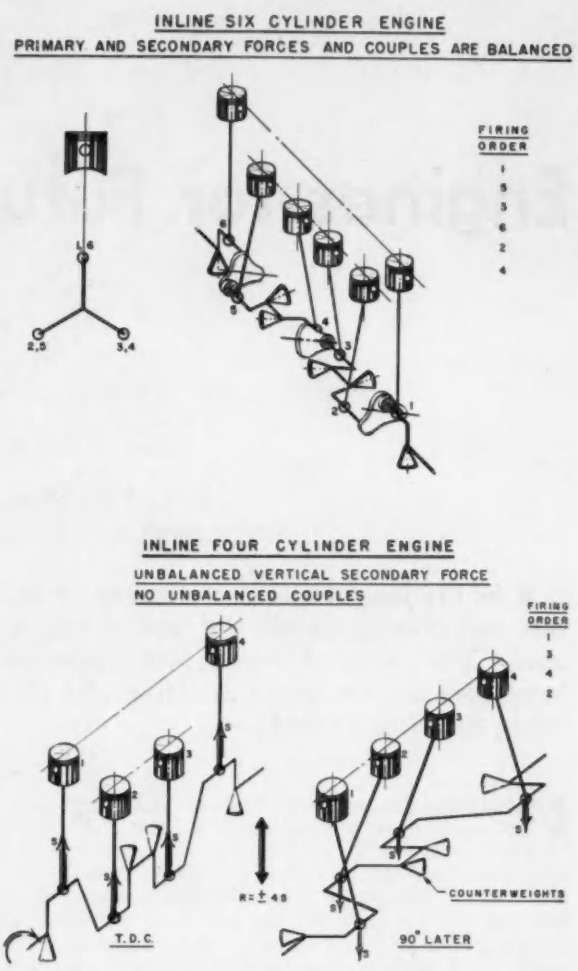
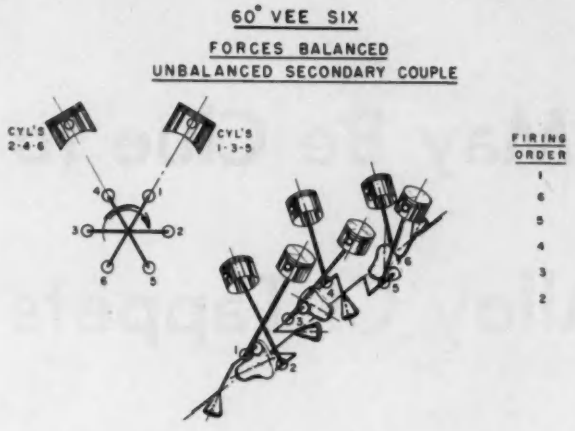


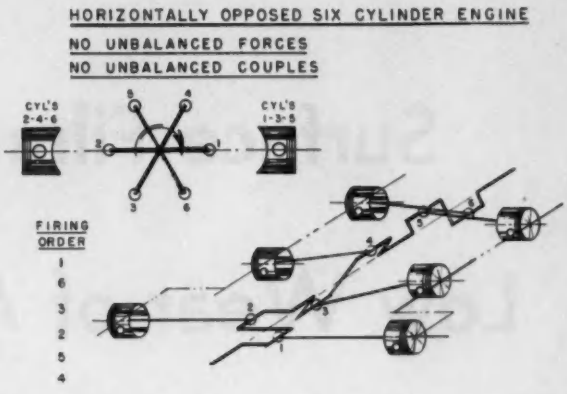
Fig. 3 — Dynamic analysis of three types of engine shows that only the 6-cyl flat and in-line engines are completely balanced for the first and second harmonics. The degree of unbalance in other

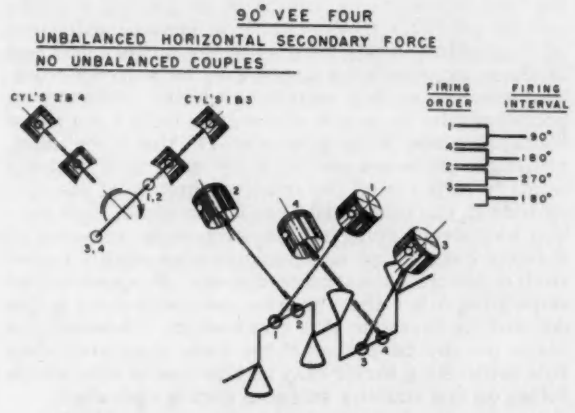
This is because the force goes up as the square of the speed. This 3000-lb force is not insurmountable as witnessed by many fine 4-cyl installations in foreign cars. However, heavier pistons and a longer stroke would further increase this force. This is why the displacement of in-line 4-cyl engines is limited to approximately 120 cu in.

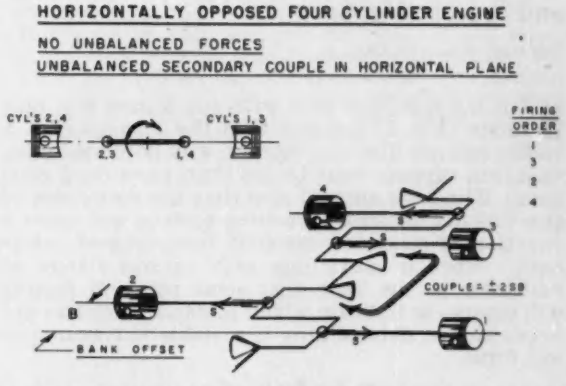
V-Six versus In-Line Six

The in-line six is expected to retain its prominence for front engine installations, especially in higher displacement engines.









combinations can be handled by good mounting design as long as the speed and size of the engine are not excessive. Couples and forces that can be eliminated by counterweights are not noted. The fact that they exist is indicated by the presence of counterweights. For example, the 60-deg V-six engine has a primary unbalanced couple that is counteracted by the counterweights shown.

For example, consider the 60-deg V-six engine. Both the primary and secondary forces are balanced, but there is a secondary couple that rotates opposite to the engine at twice crankshaft speed. The seriousness of this disturbance depends on engine size. Engines have been built that employ a counter-rotating balance shaft to counteract the couple. Since the balance shaft must rotate at twice engine speed, it has been found difficult to develop bearings and drive mechanisms.

A propeller shaft resonance may develop when the balance shaft is left off the engine. This is not too serious for small displacement engines such as the Lancia (150 cu in.). The primary couple generated by the engine is constant in magnitude and rotates with the crankshaft so it can be balanced by counterweights.

Another problem with the 60-deg V-6 is the manifold design. Equal distribution to all cylinders is difficult. Also, the bore spacing is large because a six-throw crankshaft is used. This tends to make the engine heavier and increases the water volume which is undesirable from a warmup standpoint.

These disadvantages outshadow the length disadvantage of the in-line six engine.

To Order Paper No. S143 . . .
. . . on which this article is based, turn to page 6.

Surface Film May Be Clue to Low Wear of Alloy CI Tappets

Excerpts from paper by

George H. Robinson, Robert F. Thomson, and Fred J. Webbere

Research Laboratories, GMC

HIGH contact load tests with the tappet test machine (Fig. 1) indicate that the formation of a visible surface film may explain why hardened alloy cast iron tappets wear better than carburized steel ones. The tests showed also that the formation of the visible film on the rubbing surface was more a function of specimen material than type of lubricant. Work is continuing with various classes of materials in the hope that some common factors will emerge to indicate which material variables are important in determining if a stable antiwear film will form.

Earlier Explanations

The superiority of hardened alloy cast iron over carburized steel as a tappet material is widely recognized. The difference in performance of the two materials has been attributed to various causes. For instance, it has been proposed that the graphite in the cast iron acts as a lubricant, or that the massive carbide particles in the cast iron prevent softening of the rubbing surfaces during operation. Neither of these explanations appears to be entirely valid. Tappets containing much graphite have given poorer results on bench and engine tests than those containing very little graphite. On the other hand, although performance of alloy cast iron tappets tends to improve as the relative amount of massive carbide in the microstructure is increased, high carbon tool steels, containing considerable amounts of massive carbide, do not perform appreciably better than conventional carburized steels. It appears that something other than general microstructure is the controlling factor in this application. Observations made on the tappet machine have suggested that this controlling factor may be the type of film which forms on the rubbing surfaces during operation.

Tappet Machine Tests

Fig. 2 shows that the rubbing surfaces of carburized steel and alloy cast iron wear specimens oper-

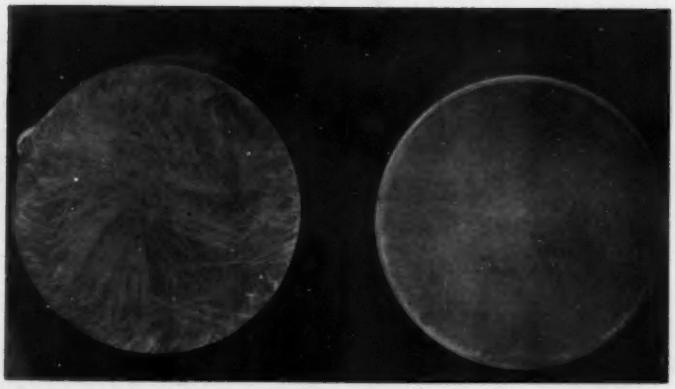


Fig. 2 — Comparison of hardened alloy cast iron (left) and carburized steel (right) wear specimens. Note surface film on cast iron.

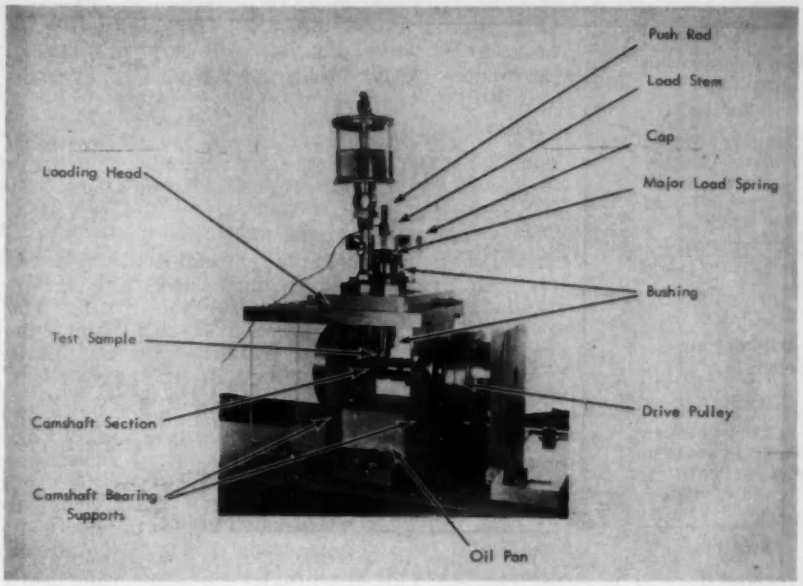


Fig. 1 — Tappet test machine, which has maximum calculated contact stress range of 100,000–300,000 psi. Originally developed to study wear behavior of automotive valve tappets and cams under simulated service conditions, the machine is now being used to make general studies of effects of materials and lubricants on wear and scuffing at high loads.

Test sample is attached to end of holder (tappet) and is held against rotating cam for spring-load push-rod. Cam sample is a section of a production automotive camshaft, containing four cam lobes, and loading head is moved to position wear specimen over desired lobe. Lubricant is metered to contact area from oil cup. Bushing that guides specimen holder or tappet, together with loading mechanism, fits in well in loading head, so that entire assembly can be removed for examination of wear specimen and replaced without disturbing system alignment.

Two separate loads are involved. Minor load is a constant force holding wear specimen against cam. It is applied by small spring inside specimen holder. As cam begins to lift sample, minor load alone acts until mechanical lash is removed. At this point, tappet sample, push-rod, and load stem begin to move together, compressing major load spring until, at maximum lift, full major load is applied. Major load is usually measured at maximum lift, by means of strain gages cemented to thin-walled load stem, and is adjusted by turning threaded cap, which compresses major load spring.

ated under similar test conditions differ considerably in appearance. The steel has a uniformly clear surface, while the surface of the cast iron appears to be partially covered with a dark film. Since steel specimens wore rapidly (approximately 0.0003–0.0004 in. in 15 min) or scuffed, while alloy iron showed no scuffing and almost no wear (approximately 0.00005 in. in 15 min) under these test conditions, it seemed possible that the visible film might be associated with the difference in performance of the two materials. The appearance of the foot surfaces of steel and cast iron specimens under a microscope is shown in Fig. 3. The steel surface appears to be relatively clean, while the cast iron is covered with a film.

The Surface Film Is Studied

The chemical nature of this visible surface film was investigated in a preliminary manner by testing the solubility of the film in various liquids. The wear surface was examined microscopically to determine the extent of dissolution of the film. The results (listed in Table 1) indicate that the film is soluble in acids, but insoluble in bases or organic solvents.

This chemical behavior suggests that the film may be an oxide of iron. Other investigators have reported that certain types of oxide films have a beneficial influence on friction and wear, both dry and in the presence of lubricants. The reason for the formation of a film on alloy cast iron and not on steel, however, is not apparent.

To check the hypothesis that the visible surface film on alloy cast iron is responsible for the superior wear and scuff resistance of this material, tests were made in which the specimen was immersed for one minute in 4% Nital before each run on the tappet machine. Other than this treatment, which was employed to remove the acid-soluble film from the rubbing surface, the test procedure was as described earlier. The results showed that removal of the film increased considerably the tendency of the specimen to fail by scuffing. (See Table 2.)

In addition to removing the acid-soluble film, the Nital treatment produced a slight roughening (etching) of the wear surface. To determine the

Table 1 — Solubility of Visible Film on Alloy Cast Iron

Solvent	Results
Ethanol	Film not affected
Xylene	Film not affected
Benzene	Film not affected
Conc. NaOH	Film not affected
50% HCl	Film removed
4% Nital	Film removed

Table 2 — Effect of Nital Treatment on Alloy Cast Iron Specimens

Test No.	Treatment	Results
1	Nital	Scuff in 1 min at 300 lb
2	Nital	Scuff in 1 min at 350 lb
3	None	No failure at 600 lb

Table 3 — Effect of Used Engine Oil (Total acid No. was 10)

Test No.	Oil	Max Load, lb	Total Wear, in.	Appearance of Wear Surface
1	Used	400-scuffed	Not measured	Bright-no visible film
2	Used	450-no failure	0.0002	Bright-no visible film
3	New	600-no failure	0.0004	Visible film (formed at 300 lb)

Table 4 — Effect of Lubricant on Film Formation

Lubricant	Load at Which Visible Film Was Detected, lb
Polyglycol	250
Paraffinic oil	200
Silicone	250
Naphthenic oil	200
Polybutene	(Failed at 250 lb)
Diester	350–400
Standard	300–350

influence of this roughening, an additional test was made by operating a specimen according to the standard procedure through the 450-lb run. The specimen was then immersed in Nital and subsequently polished with 6-micron diamond paste to remove the etched surface. When the specimen was replaced in the machine at the same load, it scuffed in 1½ min after starting, indicating that surface roughness was not a major factor in the effect of the Nital treatment.

Effect of Lubricant

The action of a weak acid such as Nital in removing the film from alloy cast iron specimens suggested that organic acids in the lubricant might have a similar effect. Accordingly, additional tests were made with a used engine oil having a total acid number of 10. The used oil was introduced at the 300-lb load portion of the test, after breaking in at 200 and 250 lb with the standard lubricant. The results showed that use of a highly acid oil does retard formation of a visible film. (See Table 3.)

The fact that one of the specimens tested with the used oil scuffed while the other did not indicates a borderline condition. Since the wear in test No. 2 was not excessive, it seemed possible that a protective film was still present in this specimen, but did not attain the thickness necessary to make it visible because of its continual dissolution by the organic acids in the lubricant. To test this possibility, the specimen from this test was immersed in Nital, to remove any acid-soluble film remaining, and rerun at 450-lb load. The specimen scuffed 1½ min after starting, suggesting that the surface film in this case, although not visible, was heavy enough to prevent gross metal-to-metal contact.

Unconventional Lubricants Studied

Since the most obvious environment factor in this study was the lubricant, a number of tests were

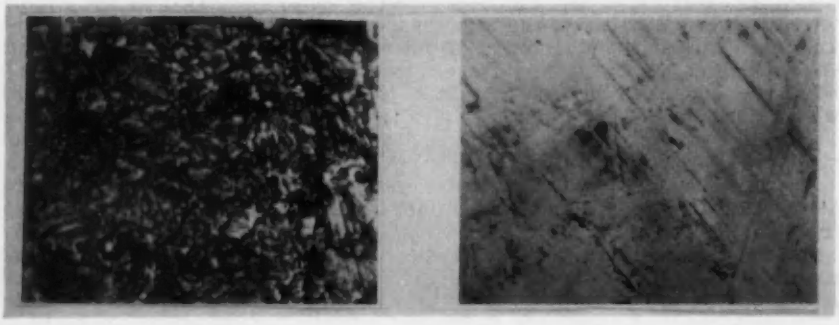


Fig. 3 — Wear surfaces after operation at 350 lb in tappet machine, using standard test oil. Note film on surface of alloy cast iron (left); whereas carburized steel surface (right) was relatively free from film. (Reduced from microphotographs taken at 500X, not etched.)

made with unconventional lubricants to investigate the influence of this factor on film formation. The normal test procedure was employed, except that the samples were pre-run 15 min at 200 lb with the standard base oil prior to operation with the test lubricant.

The results are shown graphically in Fig. 4 in terms of total specimen wear and maximum load attained before failure by scuffing or excessive wear. With the exception of the polybutene and the silicone fluids, wear was not greatly affected by type of lubricant. The loads at which visible films were detected with the various lubricants are shown in Table 4.

It is interesting to note that carburized steel tappets, which wear excessively when operated with the standard test lubricant, perform as well as alloy cast iron when the CRC oil No. 2 is employed. The latter oil is treated with a zinc dithio-phosphate additive, which presumably functions by depositing a chemical film on the steel surface.

It was, of course, not possible to determine visually that the films formed with the unconventional lubricants on alloy iron were actually the same as that observed with the standard test oil. However, it appeared that the formation of a visible film on the rubbing surface was more a function of the specimen material than of the type of lubricant. Accordingly, work has been started to study the effect of material composition on film formation. This is being done both by visual examination of the rubbing surfaces and by observation of the wear and scuffing behavior of the various materials.

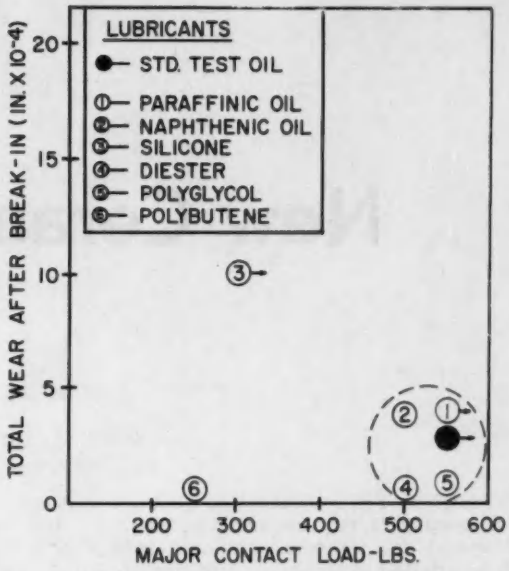


Fig. 4 — Effect of lubricant on wear. Note that, except for polybutene and silicone, wear was not greatly affected by lubricant type.

Various Materials Studied

Four general classes of materials have been investigated to date: steels, cast irons, metallic coatings on steel, and nonmetallic coatings on steel. The test results, (presented graphically in Fig. 5) indicate that the various materials fall into three groups, based on performance.

Group I, characterized by low wear, and no scuffing at loads below 400 lb, includes two types of cast iron, two steels, and a metallic coating. All of the Group I specimens developed a visible film on the rubbing surface. The Group II samples showed considerable wear and no scuffing. Included in this group are a third type of cast iron, several steels, and the nonmetallic surface coatings. A visible film was detected on only two materials of this group — both nonmetallic coatings. Either these films were of a different type than that observed on the Group I materials, or some other factor was influencing the wear process, since both materials wore excessively. The specimens in Group III failed by scuffing at such low loads that a valid estimate of the wear resistance was not obtained. This behavior may reflect a tendency of these materials to form an antiwear film that prevents proper wearing-in of the parts and yet is not sufficiently stable to prevent failure under slightly more severe conditions of operation. As yet, no explanation for the observed grouping of materials in these tests is apparent.

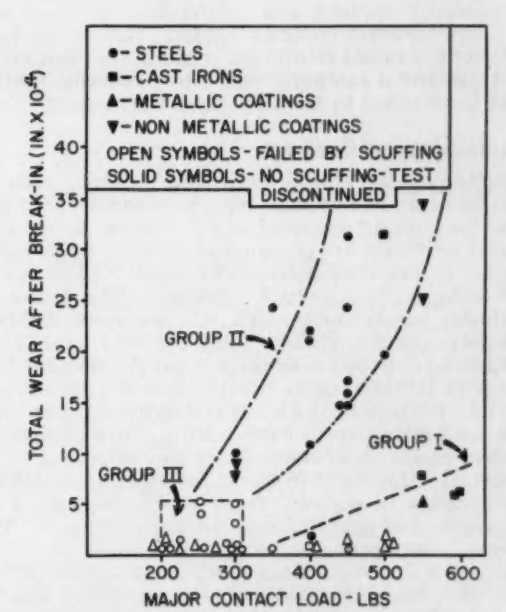


Fig. 5 — Effect of material on wear. Note that, based on performance, materials tested fell into three groups. So far, no explanation has been developed for the observed grouping of materials in these tests.

To Order Paper No. 17S . . .
. . . on which this article is based, turn to page 6.

New Ceramic Coatings Give

Based on paper by

Alan V. Levy

Marquardt Aircraft Co.

ADVANCED PERFORMANCE aircraft and missile powerplants require ceramic coatings that can withstand gas temperatures over 2000 F and that can be applied in thickness sufficient to insulate the structural base metal from severe oxidation and strength reduction effects.

Two types of coatings have been developed which successfully withstand temperatures of 3000 F and above, markedly reduce the operating temperatures of the metal components on which they are applied, and withstand the severe mechanical vibration of powerplant operation.

The first insulating-type ceramic coating to be successfully applied to a combustion chamber was a flame-sprayed ceramic oxide. The other type coating is a metal reinforced ceramic that is applied by troweling a ramming mix into a metallic matrix that is attached to the structural base metal.

Flame-Sprayed Coatings

Both powder and pressed and sintered rods of several ceramic materials have been successfully applied to suitably prepared metal surfaces by an oxy-acetyline-flame spray-gun mechanism or a detonation device that propels the coating particles at the metal surface at high velocities. The following materials have been sprayed: alumina (Al_2O_3), zirconia (ZrO_2) mullite ($3Al_2O_32SiO_2$), forsterite (Mg_2SiO_4), zircon ($ZrSiO_4$), spinel ($MgOAl_2O_3$), chromia (Cr_2O_3), ceria (CeO_2), and titania (TiO_2).

The thicknesses of the sprayed coatings vary with the application from 0.005–0.10 in., and greater in special cases. A workable thickness range for these materials runs 0.010–0.080 in. for most applications. They range in porosity from 1–16% depending on the method of spraying and the material used. The porous, overlapping-scale type structure of flame-sprayed ceramic coatings gives them a mechanical flexibility that is several orders of magnitude greater than solid body versions of the same materials. The surfaces of the as-applied coatings range in smoothness from an rms of 10 to an rms of 250. All of the coatings can be ground to surface finishes of less than rms 10. Table 1 presents the properties of some of the ceramic coatings either in production use or in the development stage.

The successful application of this type coating depends on careful preparation of the surface of the metal to be coated. Since the bond is essentially a physical one, the configuration and density of the anchoring tooth is very important.

Initial development of the flame-spray coatings used an iron shot blast to roughen the surface preparatory to coating. For static type applications where the base metal did not move elastically, this technique was satisfactory. However, for components that underwent considerable elastic deformation in service, an iron-shot prepared surface resulted in considerable coating spalling. In addition, the use of iron particles for shot left minute particles of iron imbedded in the metal surface to be coated that eventually rusted as the finished coated chamber was exposed to moisture during service. The porous nature of the coating allowed the moisture to reach the interface and attack the iron, thereby further weakening an already weak bond.

To increase the density and anchoring power of the base metal tooth and to eliminate the rusting, many abrasive grit particles of various sizes, shapes, and materials were tested applied at different pressures, angles, and distances from the metal surface. Among the materials tested were aluminum oxide grit, silica sand, garnet grit, and silicon carbide grit. The best tooth was obtained by blasting the surface with a 20 grit silicon carbide particle at approximately 60 psi air pressure. The surface produced was covered with sharp, raised ledges having extensive undercuts and re-entry angles. The ledges were estimated to provide a tooth approximately 0.005 in. high.

The final solution to the problem of anchoring the ceramic coatings was the flame spraying of a 0.002–0.005 in. nichrome metal coating before applying the ceramic. The tooth provided by the extensive stalagmites of the as-deposited nichrome resulted in the optimum physical bond between the base metal and the ceramic coating. The base metal can be prepared for the nichrome by any abrasive grit blasting. The use of the nichrome reduces the criticalness of the initial surface roughening.

Flame-sprayed ceramics are in development and in some cases production use as thermal insulating and protective coatings in the following applications: ramjet engine combustion chambers, ramjet engine and afterburner combustor components, rocket thrust chambers and exit nozzles, jetevators, turbine wheels, burner tubes, thermocouple tubes,

3000 F+ Protection

Table 1 — Properties of Flame-Sprayed Ceramic Coatings

Property	Alumina (Rokide A)	ZIRCONIA (Rokide Z)
Composition	98.6% alumina	98% zirconia
Density—lb/cu in.	0.116	0.118
Thermal drop through 0.030 in. at steady state melting temperature, deg F/0.001 in.	6	8
Maximum service temperature, deg F	3000	4200
Thermal conductivity (calculated from thermal drop data) btu/hr/ft²/in./deg F at 1000–2000 F	19	8
Emissivity at 1000–2000 F	0.3–0.4	0.3–0.4
Thermal expansion coefficient at 70–2550 F	43×10^{-7}	64×10^{-7}
Coating thickness range, in.	0.005–0.100	0.005–0.060
Porosity, %	8–12	8–12
Hardness and abrasion resistance	very high	high
Thermal shock resistance	excellent	excellent
Resistance to vibration and flexing	very good	good
Application cost per sq in./0.001 in.	0.8–1.0	1½–2

Table 2 — Properties of Reinforced Ceramic Coatings

Property	Aluminum Phosphate Bonded Alumina	Zirconium Phosphate Bonded Zirconia
Density of ceramic plus reinforcement, lb/cu in.	0.10-0.12	0.14
Thermal drop through 0.125 in. at steady state, deg F/0.001 in.	8	10
Maximum service temperature, deg F	3500	4000
Thermal conductivity (calculated from thermal drop data) btu/hr/ft²/in./deg F at 2400 F	7.2	6.0
Emissivity at 3000 F (may be modified by formulation change)	0.2	0.3-0.4
Reinforcement metal	mild steel, stainless steel, or molybdenum	molybdenum
Curing temperature, deg F	800	800
Mechanical strength	excellent	good
Thermal shock resistance	excellent	excellent
Recycling capability	excellent	fair
Resistance to vibration and flexing	excellent	good
Coating thickness, in.	0.1-1+	0.1-1+
Type of use	coating or structure	coating or structure
Material and fabrication cost	low	low

New Ceramic Coatings Give 3000 F+ Protection

. . . continued

inside surfaces of nose cones, fuel injectors, and graphite boosters and sustainers.

Most coatings in use today are alumina and zirconia. Alumina finds application where its low density can be used to advantage and where its lower melting temperature is not detrimental. Its low emissivity is also used to advantage in combustion chambers and in other areas where high reflectivity is desired. Zirconia is used where a higher melting temperature material is needed as in rocket nozzle applications.

As higher reaction or aerodynamic heating temperatures are required, the use of insulating ceramic coatings will increase. The successful spraying of other materials will extend the application of this type of thermal insulation.

The advent of higher heating sources such as the plasma jet will enable materials of higher refractoriness to be applied as coatings and markedly extend the application range of flame-sprayed coatings. Coatings for service in the 4000–6000 F range will be possible using the plasma jet flame source.

The limitations of the flame-sprayed type of insulating ceramic coatings are:

1. Maximum thickness of about 0.10 in. for economical, reliable service.
2. Long time, multicycle service has not been absolutely proven, especially on sheet metal structures.
3. Melting temperatures of the materials sprayed.
4. Limiting degree of insulation as determined by thermal conductivity and maximum thickness.

Reinforced Ceramic Coatings

Reinforced ceramic coatings are in the advanced stages of laboratory development at the present time. Several types have been developed embodying many combinations of reinforcing media and ceramic materials.

The various types and configurations of reinforcing media being investigated are:

1. Wire mesh made from mild steel, 300 series stainless steel, and molybdenum.
2. Expanded metal made from mild steel, 300 series stainless steel, and molybdenum.
3. Corrugated metal strips made from mild steel, 300 series stainless steel, and tantalum.
4. Fibers of ceramic material, primarily aluminum silicate and quartz, randomly oriented in a ceramic matrix and laminated throughout the matrix.

The types of ceramic being reinforced are:

1. Sodium silicate base composites containing various refractories such as alumina, mullite, kyanite, and silica.
2. Phosphate bonded alumina, zirconia, and chromia.
3. Pure alumina, and zirconia.

The continuous network reinforcements such as wire mesh and expanded metal are required both to reinforce the coating and to provide a means of firmly anchoring the coating to the base metal. They are brazed or resistance welded to the base metal prior to application of the coating. The fiber metal and ceramic reinforcements are mixed into the ceramic mixture prior to application. In the case of the molybdenum continuous network reinforcements, the reinforcement and base metal can be oxidation-resistance coated prior to application of the insulating ceramic.

The ceramics are applied by two methods, flame spraying as in the case of the pure alumina and zirconia and by troweling as in the case of the phosphates and silicates. In general, the reinforced ceramic materials presently being investigated for coatings do not require a high-temperature firing prior to service. The flame-spray coatings can be used in the as-applied condition; the trowel coatings usually require a baking cycle at 800 F or less.

Table 2 lists the properties of two typical reinforced ceramic coatings.

Reinforced ceramic coatings have been thoroughly flame tested in the laboratory in single and multicycle exposures. They are presently undergoing mechanical tests to determine mechanical properties. Modulus of rupture tests at room temperature on the aluminum phosphate bonded alumina type of coating, without reinforcement, have shown it to possess strengths in excess of 4000 psi. These values compare favorably with other solid ceramic bodies. The increased modulus of rupture provided by the metal reinforcement makes this composite material system attractive for severe service in structural components. Accurate determinations of their physical properties are also underway in the laboratory. They have been evaluated in full scale engine combustion chamber operation and have shown considerable promise, both from a toughness and durability standpoint and from their thermal insulation capabilities.

Fig. 1 shows how effective a reinforced ceramic coating is in providing thermal lag and steady state temperature reduction in a panel of N-155. In this

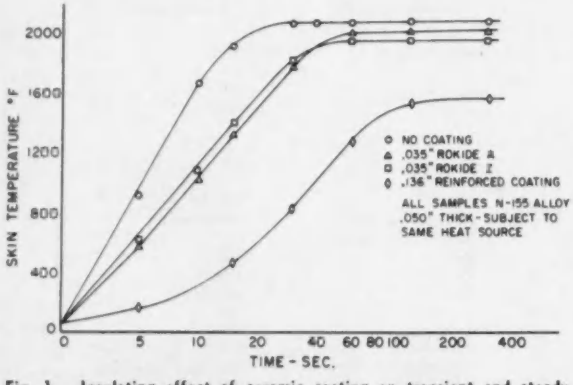


Fig. 1 — Insulating effect of ceramic coating on transient and steady state skin temperature.

test, the oxyacetylene-air torch was set to heat a bare panel of N-155 alloy 0.050 in. thick to 2100F in 30 sec. Using the same torch settings, panels of Rokide A and Z-coated N-155 and reinforced ceramic coated N-155 were tested. Note that the 0.030 in. Rokide A (alumina) and Rokide Z (zirconia) provided a temperature lag in the N-155 of 400 F for 30 sec and reduced the steady state temperature of the metal by 500 F.

The gas temperature and heat flux in this test were below those actually experienced in ramjet combustion chambers. Under actual operating conditions, especially for the higher heat fluxes experienced, even greater thermal insulation is provided.

Reinforced ceramic coatings of sufficient thickness to result in temperature reductions of several hundred degrees in the outer, load-carrying metal structure at steady state operation must be extended to higher operating temperatures. The present surface operating temperature maximum of 4000 F will have to be extended to 5000 F and above if these coating systems are to keep up with some of the advanced powerplant concepts. The use of plasma-jet high temperature sources for depositing higher melting temperature materials either in the form of full coatings or as surface coatings over a low melting temperature base material should extend this type of coating to higher temperature operation.

Refinements in application techniques and in reinforcement configuration are also fertile fields for further development. The evaluation of reinforced ceramic coatings in various applications is also needed in the near future to effectively draw these materials out of the laboratory.

To Order Paper No. 4T . . .
. . . on which this article is based, turn to page 6.

No flow calibration is necessary to get 97% accuracy when using . . .

Radioactive Tracers for Engine Airflow Measurements

Based on paper by

B. A. Fries, F. J. Davis, and D. E. Hull

California Research Corp.

ACCURATE airflow measurements for engine testing are now possible by using the total count method. Radioactive material injected into the airstream is measured by a Geiger tube and a scaler. The results are absolute, thereby eliminating the need for calibration against standard flows. Pulsating flows can be measured and a wide range of flow rates are easily accommodated.

The system works on the principle that the slower the airflow through the Geiger tube the higher the number of counts registered from a particle of radioactive material. A known quantity of radioactive material is injected ahead of the Geiger tube. The total number of counts are recorded as the material, mixed with the air, passes through the tube. The volumetric flow is then calculated from:

$$Q = FA/N$$

where:

- Q = Volume flow, cfm
- A = Quantity of tracer, microcuries (μ_c)
- N = Total number of counts (corrected for background count)
- F = Calibration factor for tube and tracer used

F is determined experimentally for a given tube and tracer. In the above equation, it has the dimension of:

$$\frac{\text{counts}}{\mu_c} \times \frac{\text{cu ft}}{\text{min}}$$

Rearranging the units to:

$$\frac{\text{counts/min}}{\mu_c/\text{cu ft}}$$

puts F in a form that can be determined by a static test of the Geiger tube. This is done by:

- Closing off the ends of the Geiger tube.
- Injecting a known amount (μ_c) of tracer into the tube.
- Recording the counts/min after the tracer is dispersed in the tube.
- Measuring the volume of the tube.
- Calculating F by dividing the counts/min by tracer emission/cu ft of tube.

The Geiger tube can then be inserted into the engine intake air circuit and used for measuring airflow rates. Since the tube doesn't restrict the airflow, the engine can operate under normally aspirated conditions. Pulsations in the flow will not materially affect the accuracy of measurements as long as the tube volume, or the total volume of air into which the tracer is mixed, is large compared to the pulse volume.

The tracer chosen is Krypton-85. It is inexpensive, has a 10-year half life for convenient storage, and its β-ray energy is suitable for counting with a sturdy, metal-wall tube.

A 97% flow accuracy can be expected with an engine inlet system incorporating the Geiger tube in its design.

To Order Paper No. 8S . . .
. . . on which this article is based, turn to page 6.

Aluminum Engine

. . . has demonstrated its weight-saving potential.

Choice of production method is still to be made.

Final cost may be less than for cast-iron counter part.

Based on paper by

George W. Niepoth

General Motors Corp.

ALUMINUM engines offer a way to gain fuel economy or performance or both without sacrificing the ride, load capacity, or comfort. They have proved their worth under test and the major question now is how best to produce them.

There are four casting methods available. These are:

1. Sand casting.
2. Semipermanent mold.
3. Permanent mold casting.
4. Die casting.

Sand casting of an aluminum block would result in much the same minimum section thickness, surface finish, and casting cost as are now met with cast-iron procedures. But the finished block would probably not be competitive with the cast-iron block in cost.

The other methods have their own advantages and disadvantages. Since all three use a metal mold, it is possible to get improved surface finish, more detailed coring, and a reduction in finish machining.

The semipermanent mold method uses a metal mold with sand cores. Normally the molten metal is gravity fed to the mold. This method would permit the casting of a water-cooled block with integral cylinder bores in a manner similar to present automotive practice.

Permanent mold technique employs a metal mold with metal cores. Castings designed for this proce-

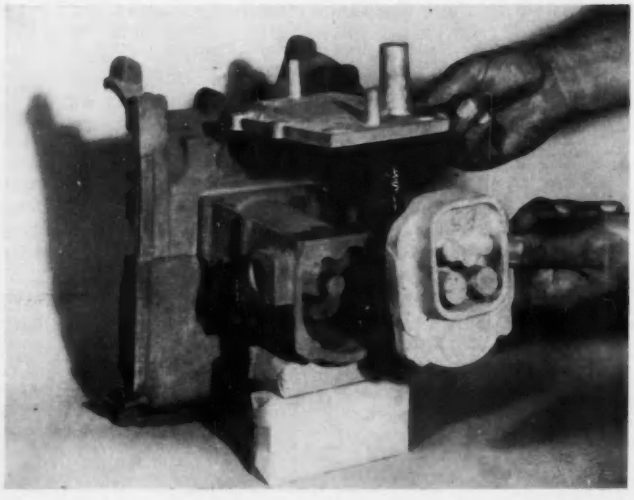


Fig. 1 — Large size die castings are completely practical. This 6-cyl in-line engine block was die cast of aluminum by Doehler-Jarvis. Block incorporates cylinder liners and an added block top deck for cooling passages.

Abridgment of an
SAE Detroit Section Paper

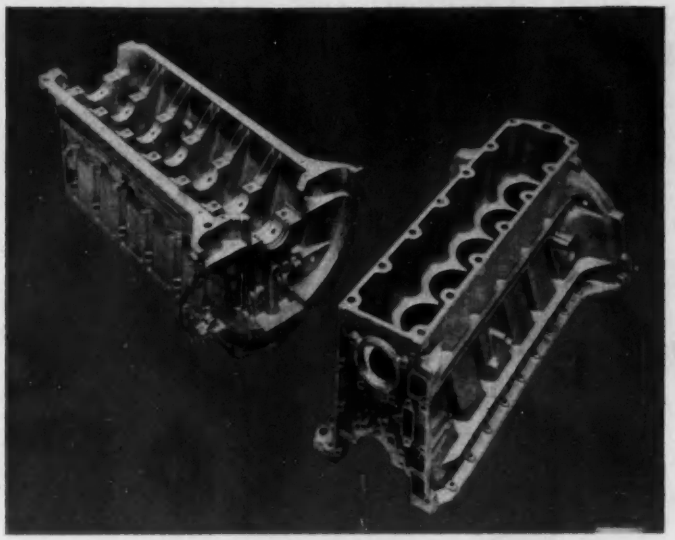


Fig. 2 — Cast aluminum engine used to drive accessories in the Firebird III. Shown is one half of engine as it was cast. Permanent mold or die cast methods could be used. Cylinder is cast integral with crankcase, using separate plates to form one side and top of water jacket.

dure, as well as for die casting, must permit removal of the metal cores.

Pros and Cons of Die Casting

Die casting uses a metal mold with the molten metal introduced to the mold under high pressure. This method will allow thinner wall sections, more castings per hour, and lends itself to automation. A considerable reduction in the total amount of metal required per casting is realized since no risers are used.

But die casting has its disadvantages. With the pressure injection of molten metal and lack of risers there is a certain amount of air entrapped in the castings. This makes it difficult to heat-treat and maintain a uniform nonporous surface. Excavation molds have been studied in an attempt to relieve this situation. Permanent mold castings, on the other hand, are essentially free of voids and lend themselves to heat-treatment.

Generally a flash of metal is encountered in die castings at the mold parting lines and this makes the use of separate retractable cores difficult. The lower pressure casting techniques allow retractable cores to be used without difficulty.

Various Approaches to Casting

Doehler-Jarvis Co. has die cast a 6-cyl in-line engine block in aluminum. This successful casting, shown in Fig. 1, proves die castings of this size to be completely practical. Designed for liquid cooling, the block incorporates cylinder liners and an added block top deck to form the cooling passages.

Aircooled cylinder barrels are now being die cast. And it is conceivable that the aircooled engine block could be die cast with integral cylinders and crankcase.

Another approach to use of die or permanent mold casting techniques has been made in the design of the aluminum engine used to drive the accessories in the Firebird III. This is a 4-stroke, 2-cyl opposed water-cooled engine with a 20 cc displacement and a compression ratio of 11/1. It is made of wear-resistant aluminum and employes a cast integral cylinder head design. One half of the engine as it was cast is shown in Fig. 2. This casting could be fabricated with either permanent mold or die cast methods. The cylinder was cast integral with the crankcase, with separate plates to form one side and the top of the water jacket.

Choice of Procedures

While all casting methods can be adapted to casting an aluminum cylinder block, the procedure chosen will most likely be based on the end cost of the finished block. Aluminum engines have been run with wet cylinder liners or with integral bores. In both cases the engines have been tested with wear-resistant aluminum cylinder bores as well as coated bores. All have been successful, so the final choice would appear to be a matter of economics.

In recent years there has been a trend toward putting aluminum casting plants adjacent to aluminum reduction plants. This permits pouring hot metal directly from the reduction cells and effects a substantial reduction in cost of casting. Couple this with improved foundry techniques and saving in machining and it indicates the aluminum engine need cost no more than its cast-iron counterpart and may actually cost less.

To Order Paper No. S145 . . .
. . . on which this article is based, turn to page 6.

Vanguard versus Sputnik

Calculations replace estimates to show how these launching vehicles really compare.

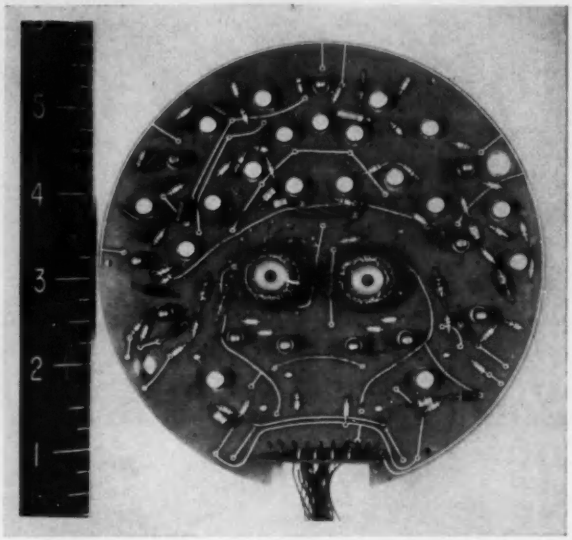


Fig. 1 — Orbital peak memory unit with orbital switch examples the trend to miniaturization in the Vanguard program.

Based on paper by **Saunders B. Kramer**
Lockheed Aircraft Corp.

Abridgment of an **SAE Northern California Section Paper**

SHORTLY after Sputnik I was launched, many estimates were advanced on both the probable size and first-stage thrust for the launching vehicle. Examination of these estimates indicates they were offered for the most part without any previous calculation, for the values were much too high.

If one assumes the Sputnik vehicle to be a "standard" three-stage tandem rocket and knows such parameters as the perigee and apogee, calculations can be made that give a rough picture of the Russian vehicle. To improve this picture assumptions are made regarding the fuel and oxidizer used, and the trajectory is approximated by the trolley-car equations in which are used an initial straightline path for stage 1, inclined some 40 deg to the local horizontal and a similar one for stage 2, inclined 20 deg.

Stage 3 is assumed to supply only additional velocity at injection into orbit. It does not add to the orbital height; the velocity is added when the vector is parallel to the local horizontal. The trolley-car equations are:

$$\ddot{s} = T/\mathrm{m} - g \sin\theta \qquad m = m(t) = m_0 - \dot{m}t$$

where

$\theta_1 = 40$ deg
$\theta_2 = 20$ deg
$g_1 = 32.2$ ft per sec^2
$g_2 = 31$ ft per sec^2
m_0 = Initial mass of rocket
$\dot{m}$ = Propellant consumption rate
s = Path length
θ = Inclination angle to local horizontal
T = Thrust

The usual logarithmic decrease of mass with time is stated explicitly in the equations. The calculation is an iterative one so that the known boundary conditions can be met with a sufficient degree of accuracy. Since good approximations are sufficient, the iterations are carried only to the extent that the boundary conditions are matched to within 5%. The results obtained in this fashion are given in Table 1.

The Vanguard vehicle is no doubt more complex and more sensitive to launching conditions than its Russian contemporary. It was designed to perform a specific task, hence major modifications may be expected before the same basic vehicle is used in attempts to launch larger satellites. The Sputnik vehicle presents a vastly different case; the same basic vehicle served to launch all three Sputniks. Moreover, evidence presented in Table 1 can be used to show the Sputnik vehicle to be either an ICBM or an IRBM, depending only on third-stage variations and the guidance program.

calculation of useful payload

A set of values on the launching vehicles, attributed to a Moscow source, became available during consideration of the various Sputnik satellites. The first- and second-stage thrust values were given as 264,000 and 79,000 lb; the total velocities at the end of first- and second-stage burning were 6600 and 17,200 fps, respectively. Since these values were at hand before the launching of Sputnik III, it was interesting to determine what the useful payload would be when these values were used. The results of the calculations are shown in Table 2. The useful

Table 1 — Comparison of Vanguard and Sputnik

	Sputnik I	Vanguard I
All-up Weight, lb	190,000	22,600
Overall Height, ft	97	72
Greatest Diameter, ft,	8	3.75
Fineness Ratio	12.3/1	19/1
Total Burning Time, sec	239	276.35
Total Impulse, lb-sec	44,742,000	4,777,850
Useful Payload, lb	185	21.5
Stage 1		
All-up Weight, lb	190,000	22,600
Diameter, ft	8	3.75
Length, ft	50	44
Mass Ratio	0.71	0.664
Propellant Weight, lb	135,000	15,000
Propellant	Lox/gasoline 2.25/1	Lox/gasoline 2.25/1
Thrust, lb	350,000	27,000
I_{sp}, lb-sec/lb at sea level	252	252
Propellant-Consumption Rate, lb/sec	1390	107
Burning Time, sec	97	140
Burnout Weight, lb	55,000	7,600
Jettison, lb	13,500	2,800
Velocity obtained	8,060 fps: 32.2% orbital	5,500 fps: 22% orbital
Height obtained, ft	188,000	190,000
Stage 2		
All-up Weight, lb	41,500	4,800
Diameter, ft	5.6	2 2/3
Length, ft	35	31
Mass Ratio	0.819	0.75
Propellant Weight, lb	34,000	3,600
Propellant	Lox/gasoline 2.25/1	WFNA/UDMH 2.8/1
Thrust, lb	83,000	7,500
I_{sp}, $\frac{\text{lb-sec}}{\text{lb}}$ at altitude	280	270
Propellant Consumption Rate, lb/sec	296	27.8
Burning Time, sec	115	129.5
Burnout Weight, lb	7,500	1,200
Jettison, lb	6,800	700
Velocity Obtained	13,630 fps: 54.5% orbital	8,000 fps: 32% orbital
Height Obtained	507,000	550,000
Total Velocity Now	21,690 fps (14,750 mph)	13,400 fps (9140 mph)
Total Height Now	695,000 ft (131.5 miles)	740,000 ft (140.5 miles)
Stage 3		
All-up Weight, lb	700	500
Length, ft	12	5
Diameter, in.	30	20
Mass Ratio	0.55	0.76
Propellant Weight, lb	378	380
Propellant	Solid	Solid
Thrust, lb	3,800	2,620
I_{sp}, lb-sec/lb	270	242
Propellant Consumption Rate, lb/sec	14.0	10.8
Burning Time, sec	27	35
Burnout Weight, lb	322	120
Jettison, lb	137	99
Velocity Obtained, fps	6,850	11,600
Height Obtained	Not applicable	Not applicable
Total Velocity Now, fps	~ 25,000	~ 25,000
Total Height Now	2,960,000 ft (560 miles)	1,585,000 ft (300 miles)
Useful Payload, lb	185	21.5

payload as calculated is 0.25% less than the weight announced by the Russian scientists, that is, 2124 lb rather than 2129.

The much lower launching weight in Table 2 as compared to that given in Table 1 is associated with both the optimization procedure and the lower initial thrust as well as with the rapid advance in rocket launching technique made during the first year after the Sputnik launching. If the Russian state of the art with respect to performance is lower than ours (a doubtful matter), the effect on these estimated data is simply to increase the initial lift-off weight without changing the final payload weight. If their performance exceeds ours, the initial lift-off weight tends to be lower, but the payload remains the same. If their state of the art with respect to structure is lower or better than the present state here, it would decrease or increase the payload shown. The author considers a lower state likely, but believes this weakness is more than balanced by the increased performance and reliability characteristics.

Table 2 — Payload Optimization for Sputnik III

(All values in lb)

Initial Lift-off	176,000
Impulse Propellant, First Stage	118,000
First-Stage Burnout	58,000
Second-Stage Launch	51,230
Impulse Propellant, Second Stage	36,886
Second-Stage Burnout	14,344
Third-Stage Launch	9,524
Impulse Propellant, Third Stage	5,524
Third-Stage Burnout	4,000
Fixed Weight	1,876
Payload	2,124

progress in miniaturization

Russian methodology leans toward using substantial off-the-shelf hardware whereas our trend has been more toward developing special equipment. Concentration on miniaturization of equipment rather than on increased performance in propulsion systems in the Vanguard program is exampled by the orbital memory switch shown in Fig. 1. The ultimate value of miniaturized instruments cannot be denied, and their optimum use will be commonplace in the large-thrust, manned vehicles of the future.

To Order Paper No. S154 ...
... on which this article is based, turn to page 6.

About SAE Members

GEORGE E. FRANCK has been made vice-president of engineering and research of Imperial Brass Mfg. Co. Prior to this, he was director of engineering for Imperial.

E. J. HRDLICKA has been made vice-president in charge of plant operation of S. K. Wellman Co. Formerly, he was general manager and general sales manager, and most recently executive vice-president for Hydreco Division of New York Air Brake Co.

FRANK R. WEMHEUER has been made president and general manager of Morgan Storage and Van Co., Inc. Formerly, he was director of operations for National Van Lines, Inc.

WILFRID A. PULVER has been made assistant general manager of Lockheed Aircraft Corp.'s Georgia Division. He will serve with assistant general manager **H. FLETCHER BROWN.** Formerly, he was chief engineer for the same company.

ROBERT F. HODGSON has been made general sales manager of Hydreco Division, New York Air Brake Co. Formerly, he was manager of engineering for Kalamazoo Division for the same company.

ROBERT E. SCHWARY succeeds Hodgson as manager of engineering with New York Air Brake Co. Schwary was formerly chief engineer for Kalamazoo Division for the same company.

JERRY M. GRUITCH has been made director of government products with ACF Industries, Inc. He will be responsible for coordinating all government product marketing activities for the company's six operating divisions. Gruitch was formerly director of defense products for ACF's American Car and Foundry division.

Franck

Hrdlicka

Wemheuer

Pulver

Hodgson

Schwary

Gruitch

Thompson

HARRY B. THOMPSON has been named chief engineer, Piston Ring Division of Hastings Mfg. Co. Formerly, he was assistant chief engineer for the same company. For the past several years he has acted as liaison for engineering between the U. S. and Canadian plants.

HAROLD P. PHILLIPS, vice-president, will continue as director of research and development of Hastings Mfg. Co. Prior to this, he was chief engineer for the same company. Phillips has been with Hastings since 1934 and has been mainly responsible for piston ring engineering.

LASKAR WECHSLER has been made head engineer of the Internal Combustion and Gas Turbine Engine Branch of the Navy Department's Bureau of Ships. Formerly, he was head engineer of the Internal Combustion Engine Section for the Department of Navy.

A. J. STEGER has been made Canadian regional manager with Bendix-Westinghouse Automotive Air Brake Co. Steger has been with Bendix-Westinghouse for 22 years and has served as Detroit regional manager for 10 years and the last two years as manager of passenger car sales.

LEE CIRILLO, manager of application engineering and special engineering on accessories and factory orders, will be relieved of his present duties in order to devote his full time to new product and market research for Towmotor Corp.

WILLIAM E. LIND is head of engineering and manufacturing of Automotive Air Conditioning Division, Lindustries, in Ft. Worth, Texas. Formerly, he was manager for Cab, Bus & Refrigerated Transport Division, Frigikar Corp. Lind is past-chairman of SAE Texas Section.

Phillips

Wechsler

Steger

Cirillo

Lind

Hoffmann

CHARLES P. HOFFMANN, JR., has been made sales engineer with Hydro-Aire Co., a division of Crane Co. Prior to this, he was automotive engineer for American Trucking Associations, Inc.

VINCENT P. MASI has been named plant manager of the Trenton Engine plant of Chrysler Corp. Prior to this, he was manufacturing manager for Trenton Engine plant.

WILLIAM H. GRAVES, professor of automotive engineering and director of Automotive Engineering Laboratory at the University of Michigan, has been named a director of Detroit Harvester Co. Graves was 1947 SAE vice-president representing Passenger Car Activity.

LAWRENCE A. ZWICKER has been made director of engineering and sales with Harrison Radiator Division, General Motors Corp. Prior to this, he was chief engineer for the same company.

DAVID ROY SHOULTS, general manager, Aircraft Nuclear Propulsion Department of General Electric Co., received an award in recognition of his individual achievements as an engineer in industry from the Technical and Scientific Societies Council. Shoults was 1952 SAE vice-president representing Aircraft Activity.

ERIC HAMM has been made managing engineer with Ore-Lube Division, Brance-Krachy Co., Inc. Prior to this, he was lubrication engineer for Imperial Metallic Lubricants. He is a member of the governing board of SAE Texas Gulf Coast Section.

GEORGE ROMNEY, president and chairman of the board of American Motors Corp., has been honored by "Saturday Review of Literature" as 1959 Business Man of the Year.

WILLIS M. CLARK, JR., is now senior engineer — design with Rocketdyne Division of North American Aviation, Inc. Formerly, he was product design engineer A for Ford Motor Co.

WILLIAM J. SONNEMAKER has been made assistant to the manager, facilities division, with Missiles and Space Division of Lockheed Aircraft Corp. Formerly, he was staff assistant to the president of Pesco Products Division, Borg-Warner Corp.

RICHARD L. HUMPHREY is now engineer — trainee with Aro, Inc. Prior to this, he was a student at the Missouri School of Mines.

CDR. LOU CIARROCCA (USN) is now production planning officer at the Quonset Point, R. I., Naval Air Station. Prior to this, he was a powerplants and nuclear energy officer.

WILLIAM V. LUNEBURG has been made vice-president of Mather Spring Co. Prior to this, he was plant manager for Ford Division, Ford Motor Co.

NIELS J. BECK has been made director of advanced design and development with Cummins Engine Co. Formerly, he was chief of the propulsion section for Douglas Aircraft Co., Inc.

THOMAS F. BURKE is now territory manager with Champion Spark Plug Co. He was formerly sales manager for the same company.

EVERARD P. LARNED is now development engineer, Airtomic Division with C. Lee Cook Co., Division of Dover Corp. Formerly, he was sales engineer for Metal Products Division of Koppers Co., Inc.

EDWIN C. WATSON has been made supervisor, manufacturing methods standards with Light Military Electronics Department of General Electric Co. Formerly, he was supervisor, analysis and information for Westinghouse Electric Corp.

FRANK G. ELMINGER is now design engineer with Delta Design Engineers. Prior to this, he was design engineer for TAB Engineers, Inc.

WETMORE HODGES, JR., is now head, support systems, new design department of Lockheed Missiles and Space Division, Lockheed Aircraft Corp. Formerly, he was president and manager of operations for Locomotion Engineering, Inc.

CHARLES W. McALLISTER has been made manager technical service — aviation sales with Sinclair Refining Co. Formerly, he was chief aviation engineer for the same company.

GREGORY J. SIRAGUSA is now Northwestern representative of Wilson Meyer Co. He has his headquarters in the Seattle district office of the firm. Siragusa was formerly manager, Western Regional Laboratory for E. I. du Pont de Nemours & Co.

RICHARD CHARLTON HUGHES has been made technical manager of British Light Steel Pressings, Ltd. He was formerly chief quality engineer for Commer Cars, Ltd.

FRANCIS J. EAMES has been made director of engineering with Massey-Ferguson S. A. in Paris, France. Prior to this, he was chief engineer for Massey-Ferguson GmbH in Germany.

O. A. WHEELON has been elected to the Board of Directors of Beryllium Corp. He is now in the consulting engineering field with Wheelon Engineering and Research Consultants.

WALTER G. BAIN has become vice-president of Radio Corp. of America. Prior to this, he was vice-president and general manager for Republic Aviation Corp.

L. S. KRON has been made assistant chief military engineer, Military Vehicle Engineering Agency of Diamond T Motor Truck Division, White Motor Co. Formerly, he was chief draftsman, Military Engineering of Diamond T.

JACK L. BARNES is now a truck specialist with Hatfield Motors, Inc. Prior to this, he was president of Jack Barnes, Inc.

EDWARD P. ESPENSCHIED is now a mechanical engineer with Fischer and Associates, Inc. Formerly, he was a designer for Joy Mfg. Co.

JOHN R. LONG, JR., is now self-employed in purchasing parts and equipment for South American marine, construction, drilling, and mining companies. Formerly, he had been president-manager of Long's Engine Service, C. A., Venezuela.

B. NEIL LEWIS has been made office engineer with Charles C. Redman, Jr., civil engineers and surveyors. He had been a graduate in training for the engineering staff of General Motors Corp.

CHARLES R. BARBOUR has become supervisor, proving grounds administration section, with Ford Motor Co. He was formerly supervisor, scheduling and records section, Dearborn Test Area Department of Ford.

JACK B. HURT has been made senior propulsion design group engineer with Convair Division of General Dynamics Corp. His responsibilities cover the design of the propulsion systems for the F-106, 880, 600 as well as other undisclosed configurations. Formerly, he was senior designer for Convair.

DR. CLYDE WILLIAMS, president of Clyde Williams and Co., has been named recipient of the James Douglas Gold Medal of the American Institute of Mining, Metallurgical, and Petroleum Engineers. It was presented to Williams at the annual national banquet of AIME in San Francisco.

PHILIP H. PRETZ and **VICTOR G. RAVIOLO** have joined the firm of Great Lakes Airmotive, Inc., as investing partners and vice-presidents. Pretz was formerly director of Testing Operations Office for Ford Motor Co. Raviolo was formerly special assistant to the vice-president for Ford Motor Co.

Continued on next page

SAE Father And Son

GROVER C. WILSON, engineering department, California Western University, San Diego, is shown with his son **ROBERT E. WILSON,** group project engineer, Lycoming Division of Avco Mfg. Corp. Both father and son are members of the SAE Diesel Engine Activity Committee. Grover C. Wilson was 1943 SAE vice-president representing Diesel Engine Activity.

WALTER L. HARDY is now manager, chemical research and development with International Minerals and Chemical Corp. Formerly, he was director of engineering for Foster D. Snell, Inc.

JESSE G. HAYMES, JR., is now production design liaison engineer with Douglas Aircraft Co. Formerly, he was designer for Pratt & Whitney Aircraft Division, United Aircraft Corp.

HERMAN DVORAK is now a senior mechanical engineer with Missile and Space Systems Division of United Aircraft Corp. Formerly, he was a technical specialist for Aerojet-General Corp.

BILL L. COFFEY has been made research engineer with Missile Systems Division, Lockheed Aircraft Corp. He was formerly a test engineer for Rocketdyne Division of North American Aviation, Inc.

OTTO EDWARD SZEKELY has been made president and chairman of the board of Szekely Engineering & Mfg., Inc. Formerly, he was president of O. E. Szekely and Associates, Inc.

DONALD H. NELSON has been made production engineering manager with Highland Park Mfg. Plant of Chrysler Corp. Formerly, he was administrative manager of manufacturing services for the same company.

EVERETT C. CURTIS has been made chief engineer with Towmotor Corp. Formerly, he was assistant chief engineer for the same company.

WILLARD A. MURRAY is now director of engineering with Brookside Corp. Formerly, he was chief hydraulic engineer for C. W. Smith Engineering Co.

IRVING T. BARTLETT, JR., is now sales engineer with Packaged Industrial Power, Inc. Formerly, he was eastern sales manager for United States Motors Corp.

KENNETH ARNE KUJANSON is now a field engineer with Ordnance Division of Minneapolis-Honeywell Regulator Co. Formerly, he was a design analysis engineer for the same company.

NED P. KIMBERLY has been made assistant manager, automotive sales for Johns-Manville Sales Corp. Prior to this, he was manager, automotive sales for L-O-F Glass Fibers Co.

WILLIAM C. HESTER is now director of client service with Beltaire, Vincent, and Hull, Inc. Formerly, he was aeronautics publications manager for Vickers, Inc., Division of Sperry Rand Corp.

FREDERICK C. BOWMAN is now district manager with Atlantic Refining Co. Prior to this, he was manager, wholesale marketing, East Pennsylvania Region for the same company.

LARS GEORG ROMBERG is now senior engineer for Transport Division of Boeing Airplane Co. Formerly, he was assistant to the president for Scandinavian Airlines System, Inc., in Sweden.

WINTHROP B. VAIL has become manager, engineering service with Hoover Ball & Bearing Co. Formerly, he was supervisor, agricultural and textile applications for New Departure Division, General Motors Corp.

ROY S. TUCKER has been made industrial sales manager with Massey-Ferguson, Inc. Formerly, he was manager, Truck and Machinery Division of Schuman Carriage Co.

ERWIN F. GRIMMEISEN has become president of James L. Howard & Co. He was formerly engineering manager for Hartford Screw Co.

DAVID R. KIMBER is now sales engineer with Lubrizol Corp. Prior to this, he was research engineer for E. I. duPont de Nemours & Co.

REGINALD WHITSON has been named manager of government projects with Warner Electric Brake & Clutch Co. Formerly, he was manager of management services for Warner.

MALCOLM McLOUD has become sales manager for battery separators with Evans Products Co. Prior to this, he was assistant sales manager for U. S. Rubber Co.

JAMES J. ROBSON, director of tire engineering and development of Firestone Tire and Rubber Co., has been elected president of Tire and Rim Association, Inc. He succeeds **PAUL G. HYKES,** executive engineer of Budd Co.

DR. PAUL ZIVKOVICH has become general manager of the new Prototype Division of Mardigian Corp. Prior to this, he was executive vice-president of Hart Metal Products Corp.

Whitson

McLoud

Robson

Zivkovich

THOMAS A. MROZ is now supervisor of non-destructive tests at Olin-Mathieson Chemical Corp. Formerly, he was quality control engineer in charge of control rods for Swindell Dressler Corp.

PATRICK J. DeLUCA, JR., is now senior stress engineer with Comprehensive Designers, Inc. Formerly, he was senior stress analyst for Emerson Electric Mfg. Co.

FRED W. HANEY, JR., is now development engineer at Aerojet-General Corp. Formerly, he was senior development engineer, Aircraft Engine Division for Ford Motor Co.

CHARLES R. LIMBACHER is now a mechanical engineer with Magnavox Co. Prior to this, he was a mechanical engineer for Picatinny Arsenal, Ordnance Corps.

ALBERT O. ROBERTS, JR., is now an assistant chief engineer with Vickers, Inc. He was formerly project engineer for the Edsel Division of Ford Motor Co.

M. P. FERGUSON, president of Bendix Aviation Corp., has been made a member of the Board of Directors of the National Bank of Detroit.

WILLIAM R. THOMAS is now a research engineer with Caterpillar Tractor Co. Prior to this, he was a design engineer for Caterpillar.

WILLIAM R. ALLEY, JR., is now regional engineer at Janitrol Aircraft Division, Surface Combustion Corp. Formerly, he was group engineer — heat exchangers for the same company.

JOHN W. COLLINS, JR., has become Detroit district sales manager with Aluminum Co. of America. Formerly, he was assistant district sales manager for the same company.

DON VERNOR ROWTON is now associated with Hydrodyne Corp. Prior to this, he was associated with Pacific Division of Bendix Aviation Corp.

H. W. SMALL has been made assistant to the vice-president, Automotive Division of Clark Equipment Co. Formerly, he was sales manager with Automotive Division of Gunite Foundries Corp.

W. J. KOPPIUS has been made chief of research and development with Gits Bros. Mfg. Co. Prior to this, he was gas turbine research engineer, Engineering Division of Chrysler Corp.

M. THOMAS VICTOR, president of International Powder Metallurgy Co., was elected first vice-president of the Powder Metallurgy Parts Manufacturers Association.

LAWRENCE H. HODGES has been made works manager with J. I. Case Co. Formerly, he was assistant works manager for the same company.

ROBERT R. ROTH has been made chief product engineer with J. I. Case Co. Formerly, he was assistant chief product engineer with the same company.

FRED J. WALLS has been made vice-president — research and development of Engineering Castings, Inc. Formerly manager of the Detroit Technical Section of International Nickel Co. until his retirement last October, Walls has been associated with Engineering Castings as a stockholder and director since the inception of the company in 1946.

HAROLD R. HIGDAY is now assistant chief engineer with KW Dart Truck Co. Prior to this, he was assistant chief engineer — trucks for Pacific Car and Foundry Co.

LEONARD J. MacDONALD is now general superintendent of equipment with Highway Paving Co., Ltd. Previously, he was general manager for Ottawa Transportation Commission.

GERALD W. COLBY has been made chief filter engineer with Seymour Filter Co., a new subsidiary of Cummins Engine Co. Prior to this, he was senior project engineer for AC Spark Plug Division of General Motors Corp.

HARVEY I. KRAM has been named operations consultant to the president of Revelon, Inc. He was formerly director of manufacturing for Leviton Mfg. Co., Inc.

HENRY W. CALLIHAN has been made group engineer in charge of propulsion systems for the Convair 600 Transport, Convair Division of General Dynamics Corp. Formerly, he was assistant group engineer for Convair.

RALPH L. BAYLESS, chief engineer, Convair Division of General Dynamics Corp., (San Diego, Calif.,) has been named a fellow of the Institute of Aeronautical Sciences. Bayless accepted the honor at the annual IAS Honors Night dinner in New York City.

ERNST W. PORTMANN has been named technical director of Metal Products Division, Fluor Products Co. Prior to this, he was associated with Hartmann Division of the same company.

WILLIAM C. WOODWARD has been made manager of aircraft and missile sales with Aluminum Co. of America in Pittsburgh. Prior to this, he was manager of forging sales for the same company.

D. W. EVANS, application engineer, will supervise the activities of the Application Engineering Group at Towmotor Corp.

DR. DONALD N. FREY, executive engineer at Ford Division, Ford Motor Co., has been awarded the Detroit Junior Board of Commerce's 1959 Distinguished Service Award.

ROBERT E. CUMMINGS, manager of Thompson Products Valve Division of Thompson Ramo Wooldridge, Inc., has been made vice-president of the corporation.

CARL L. KAHLERT, manager of Thompson Products Replacement Division of Thompson Ramo Wooldridge, Inc., has been made vice-president of the corporation.

JOHN A. RIZZARDI is now manager with Hoskins Alloys of Canada, Ltd. Prior to this, he was research engineer for Hoskins Mfg. Co.

GEORGE E. LIGHT has been made product supervisor — petroleum additives with Amoco Chemicals Corp. He was formerly sales engineer for the same company.

ARTHUR LEONARD OTT, JR., is now a design engineer with Bell Aircraft Corp. He was formerly a designer for Saginaw Steering Gear Division of General Motors Corp.

Obituaries

J. DILLARD COLLINS . . . (M'57) . . . vice-president of engineering of Hudson Lamp Co. . . . died January 10 . . . born 1912.

FRANCIS E. CUNNINGHAM . . . (A'42) . . . vice-president of James Cunningham, Son & Co., Inc. . . . died November 26 . . . born 1883.

CLIFFORD N. HOUSE . . . (M'19) . . . sales engineering agent for Ahlberg Bearing Co. . . . died January 28 . . . born 1892.

NORTON B. MOORE . . . (M'39) . . . president of Norton B. Moore & Associates . . . died December 11 . . . born 1909.

WALTER W. SCHEUMANN . . . (M'41) . . . vice-president of Cities Service Research and Development Co. . . . died October 5 . . . born 1901.

ROBERT M. TULLOS . . . (A'54) . . . general service manager with Reo Division, White Motor Co. . . . died October 25 . . . born 1911.

Rambling . . . Through

Inventory control of 70,000 parts' numbers is maintained at IHC's Baltimore Parts Depot, first and pilot model of the company's 12 depot operations. Through electronic computers, accounting and handling of items is done for the geographic area from New York to South Carolina . . . with three months supply on hand, according to calculated demand for each particular part. Automatically, when minimum inventory is reached, the depot replenishes the supply for motor trucks, crawler tractors, construction equipment, farm and utility tractors, and other farm machinery. **Annual shipments from the Baltimore Depot currently exceed a net value of $30,000,000.**

Examining the facilities (above) are members of the **BALTIMORE SECTION** during their tour of the Depot.

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Although only 6% of the cost of a commercial vehicle is contributed by electrical equipment, 20% of vehicle failure is due to electrical mechanisms. Delco-Remy's H. L. Hartzell attributes these failures to the use of low-cost automotive equipment being mis-applied to heavy-duty, high-load operations.

Maximum electrical load on a tractor-trailer combination is 50 amp with a 12-v system . . . large intercity buses need about 130 amp in a non-air-conditioned vehicle and over 200 amp in an air-conditioned bus.

Hartzell advised, at **TWIN CITY SECTION,** the consideration of the following types of generating equipment:

- Heavy-duty d. c. generators for loads up to about 40 amp.
- Alternating current generators with silicon rectifiers for loads in the range of 50 amp.
- Alternating current generators, oil cooled, and with silicon rectifiers, for loads up to 225 amp.

• • •

The painstaking job of recovering, examining parts, and collecting all known data of aircraft accidents was explained to **SOUTHERN NEW ENGLAND SECTION** members by Joseph Fluett, inspector in charge, N. Y. C. A. B. Lengthy, exhaustive investigation of parts, flight paths, pitch, attitude, etc. — as well as statements from all witnesses and survivors — were explained by Fluett as the only valid way to reveal true causes and contributing factors of accidents.

Utilization of investment casting process to produce larger and heavier castings is foreseen in the future by Norman Gershman, chief estimator at Arwood Precision Casting Corp. Recent developments in technique point to production of castings over the current limit of approximately 25 lb. (**WILLIAMSPORT GROUP** in February.)

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Examining a jet engine and rollover stand at United Air Lines' San Francisco maintenance facility are: left — Robert Swan of Resistoflex Corp.; and right — Ralph Cramer, **NORTHERN CALIFORNIA SECTION'S** Student Committee chairman.

The Northern California Section members played host to 100 engineering college students for a tour of the UAL base and a technical meeting featuring a talk by William C. Mentzer, UAL's vice-president, engineering. The tour included an inspection of the overhaul docks and piston engine overhaul facility. Close-range examinations were made of aircraft and jet engines.

Speaker Mentzer described the selection of jet aircrafts for commercial operation. He concluded that due to the attainment of swept-wing design, high speed and altitude flying, and improved high-power J-57 Pratt and Whitney engines — the jet aircraft can now provide cost-per-seat-mile competition with the highly developed piston power aircraft.

The Sections

SAE President Leonard Raymond met with the **MOHAWK-HUDSON SECTION** in February — following a tour of ALCO Products, Inc. Guiding the tour was P. S. Vaughan (top left), ALCO's chief engineer-diesel engine design — onlookers are Raymond (top right); O. G. Dellaconica (bottom left), ALCO commercial engineer, export locomotive projects; Hollister Moore, manager SAE Sections and Membership Division; and P. E. Kezer (bottom right), past-chairman of the Mohawk-Hudson Section.

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A group of **MID-MICHIGAN SECTION** members (below) during their inspection tour of three Chevrolet plants in the Flint area. R. W. Podesak, Chevrolet's regional manufacturing manager, addressed the group on modern production techniques following the tour.

GMC's Director Charles S. Mott, left (photograph at left), and Section Past-Chairman Earl Wilson, Sr., right, at Mid-Michigan Section's Flint-area meeting.

Rambling . . .

Through the Sections

continued

Two first prizes were awarded to students at **CENTRAL ILLINOIS SECTION'S** annual student-paper competition meeting in February. Four Enrolled Students, from Bradley University and the University of Illinois, made presentations . . . co-winners of first prize were **Ray Erler** from Bradley and **Ralph Bunting** from the Univ. of Ill.

Erler discussed "Engineering Education", advocating that engineers should have a well-rounded curriculum in college to supplement their technical training. Since more engineers are becoming managers, Erler explained, they need to learn at an early stage how to "deal with men and their ways," in addition to "things and their forces."

Co-winner Bunting addressed the Section on "The Story Behind the Volkswagen" . . . explaining why the vehicle has needed such little basic adjustment in design, engine features, etc., in its lifetime.

Papers were also presented by **Nicholas Hertelendy** of Bradley on "Interferometers" and **George Miller** of the Univ. of Ill. on "The Future of the Aluminum Engine."

Professor William Hull from the University of Illinois was technical chairman for the meeting.

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DR. W. F. HUGHES has replaced **DR. W. F. STOKEY** as faculty advisor of the Carnegie Institute of Technology's SAE Student Branch. Stokey has been the faculty advisor for the group since it was chartered in 1951.

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C. R. STOCKARD has taken over the chairmanship of the **ATLANTA SECTION,** replacing **P. W. GODARD.** Past-Chairman Godard has become owner of Wand Rubber Stamp Works in New Orleans. Before assuming his new duties, Stockard was Section vice-chairman . . . **J. FOREST COLLINS** has replaced him in the vice-chairman post.

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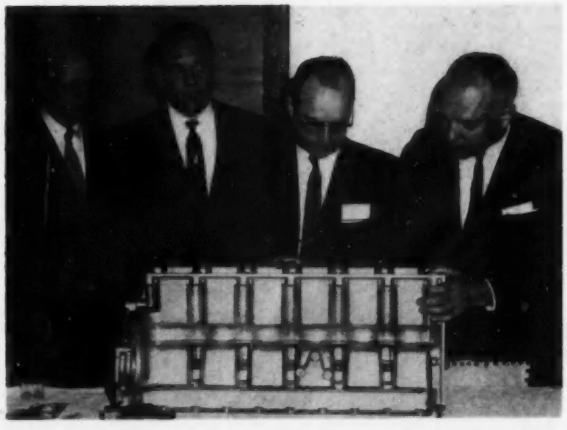
E. P. WHITE, chairman of the SAE Student Committee, has recently become **PITTSBURGH SECTION'S** secretary. To assume his new Section responsibility, White resigned as Section Placement Committee chairman, and has been replaced by **ARTHUR SLAGLE** in that post.

Initial technical meeting of SAE'rs in the Rockford-Beloit-Janesville area was held February 16 . . . 250 engineers attended and endorsed proposals for additional local SAE activities in the Rockford-Beloit area. Featured speaker at the meeting was Max Roensch, director of Chevrolet's new research and development laboratory.

SAE members prominent in the group's planning include (front from left): D. L. Cauble, chief engineer, Sunstrand Aviation Division, Sunstrand Machine Tool Co.; Speaker Max Roensch; Hollister Moore, manager, SAE Sections and Membership Division; and Leo Lechtenberg, Milwaukee Section vice-chairman. Second row (from left) E. J. Rentzinger, designer, Fairbanks Morse & Co.; T. M. Robie, president, Eibor Services, Inc.; Roger Birdsell, vice-president, Yates-American Machine Co.; W. C. Arnold, chairman of the organizing committee; R. C. Wallace, liaison officer between Chicago Section and the proposed group; and Dean Thomas, Milwaukee Section chairman.

Next meeting for the group is scheduled for April 21, with a plant tour of the Woodward Governor Co. in Rockford and dinner at Forest Hills Country Club.



Joint meeting of **NORTHERN CALIFORNIA SECTION** and its **SOUTH BAY DIVISION** was held in February, featuring A. F. Bauer speaking on aluminum die cast engine blocks. Bauer is assistant general manager and chief engineer of National Lead Co.'s Doehler-Jarvis Division.

Examining a Kaiser 6-cyl die cast engine are (left to right) SAE Past-President C. G. A. Rosen; Speaker Bauer; F. W. Fingerle of Food Machinery and Chemical Co.; and L. F. Swoboda of Kaiser Aluminum and Chemical Sales, Inc.

sae section meetings

ALBERTA

May 8 . . . "The Magic Suitcase." E. I. du Pont de Nemours & Co. factory representative. The Elks Club Room, 7th Ave., West, Calgary. Dinner 7:30 p.m. Meeting 8:15 p.m.

BALTIMORE

May 14 . . . Marvin Whitlock, vice president, American Airlines. "Jet Airliners." Friendship International Airport. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Father and Son night.

BUFFALO

May 20 . . . John Fitch, consultant, Briggs-Cunningham Co. "Grand Prix Racing." Buffalo Trap & Field Club, Cuyuga Road. Sports car show & judging 4:00 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

CENTRAL ILLINOIS

May 25 . . . C. Gordon Benett, Jaguar Cars Ltd. "Sports Car Racing." Coffee speaker: Glenn I. Branstad, research engineer, Caterpillar Tractor Co., "Activities of Illinois Valley Sports Car Club." Pere Marquette Hotel, Peoria. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Feature: Sports car exhibit.

CLEVELAND

May 9 . . . Dinner Dance. Cleveland Engineering & Scientific Center. Paul Burton's Orchestra.

May 11 . . . Transportation and Maintenance Activity Meeting. Three afternoon sessions, followed by cocktail hour and dinner. Special guest will be SAE President Leonard Raymond. Evening Speaker: Father Birkenhauer.

COLORADO

May 4 . . . SAE President Leonard Raymond, special guest.

DETROIT

May 4 . . . Junior Activity. Tour of Detroit Arsenal, Centerline, Mich. 1:00 p.m.

May 11 . . . "The Stylist, the Engineer, and Tomorrow's Market." Speakers: Eugene Bordinat, chief stylist, M-E-L Studio, Ford; O. K. Kelley, chief engineer, Buick Motor Div., GMC; Herbert Fisher, director of consumer research, Chrysler. Dinner speaker: Duffy Daugherty, head football coach, Michigan State Univ. Rackham Educational Memorial. Dinner: 6:30 p.m. Technical session: 8:00 p.m. $3.25 per plate.

May 23 . . . Ladies Night, Dinner-Dance. Statler Hotel. $20.00 per couple.

INDIANA

May 20 . . . Annual Race Meeting and Ladies Night. Speaker will be Peter DePaolo. Indianapolis Athletic Club Ballroom. Cocktail Hour from 6:00 p.m. to 7:30 p.m. Dinner 7:30 p.m. Meeting 8:30 p.m. Special feature will be the showing of the 1958 race.

KANSAS CITY

May 6 . . . Dinner Meeting. Richards-Gebauer Air Force Base, Officers Club, Grandview, Mo. Special Guest: SAE President Leonard Raymond. Dinner 6:30 p.m. Tour of base 8:00 p.m.

METROPOLITAN

May 15 . . . Golf Outing. Dinner Dance. Sleepy Hollow Country Club, Scarborough-on-Hudson. Starts at 12:45 p.m. Special Feature: Sponsored Cocktail Hour.

MID-CONTINENT

May 1 . . . Annual Ladies Day. Social hour and dinner will precede the meeting at 8:00 p.m. Chester A. Lauck, Continental Oil Co., will be principal speaker. Special guest: SAE President Leonard Raymond. Western Hills Lodge, Sequoyah State Park, Okla.

MILWAUKEE

May 1 . . . William F. Hofmeister, chief metallurgist, Chain Belt Co. "Practical Application of the Cumulative Fatigue Damage Theory." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

May 25 . . . Panel Discussion on Automotive Materials. Mount Royal Hotel. Reception 6:15 p.m. Dinner 7:00 p.m. Meeting 7:45 p.m.

NEW ENGLAND

May 5 . . . Robert C. Norrie, general manager, Kenworth Motor Truck Co. "What Influence Truck Design." M.I.T. Faculty Club, 50 Memorial Drive, Cambridge. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: movies and slides.

PHILADELPHIA

May 1 . . . Ladies Night. Dinner-Dance. Springhaven Country Club.

PITTSBURGH

April 28 . . . Student Meeting. O. J. Schwarm, director of guidance, Pittsburgh Prep School. "Engineering Preparatory Education."

May 21 . . . R. J. Kluberton, E. I. du Pont de Nemours & Co. "Paint it and Paint it Right." Venango Country Club, Reno, Pa. Dinner 6:30 p.m. Meeting 8:00 p.m.

ST. LOUIS

May 12 . . . M. G. Bullock, and Jay Tipton, Transit Casualty Co. "Safety Engineering." Ambassador-Kingsway Hotel, 108 N. Kings Highway. Dinner 7:00 p.m. Meeting 8:00 p.m.

SOUTHERN NEW ENGLAND

May 6 . . . Ladies Night. Farmington Country Club.

SPOKANE-INTERMOUNTAIN

May 13 . . . Student Night. Two speakers from University of Idaho, two speakers from Washington State University. Student Union Building, University of Idaho, Moscow, Idaho. Dinner 6:30. Meeting 7:30 p.m.

TEXAS GULF COAST

April 23 . . . Dr. Dale Leipper, professor of Oceanography & Meteorology, Texas A. & M. College. Dinner 6:00 p.m. Meeting 6:45 p.m. Special Feature: Special events meeting with the Texas A. & M. Student Group at College Station, Texas.

VIRGINIA

May 25 . . . Ladies Night. William Byrd Hotel, Richmond. Dinner 6:30 p.m.

WASHINGTON

May 19 . . . Ladies Night. Dinner Dance. "St. Lawrence Seaway."

WESTERN MICHIGAN

May 5 . . . Student Night. Dr. Otto of University of Michigan to be speaker. Film of the 1958 Indianapolis Auto Race. Doo Drop Inn, Muskegon, Mich.

WICHITA

May 7 . . . Ladies Night. SAE President Leonard Raymond. Innes Tea Room, Broadway at William. Social Hour 6:30 p.m. Dinner 7:15 p.m. Meeting 8:15 p.m.

Early Development of Specs for Reinforced Plastics Aim of New Group

AUTOMOTIVE engineers and designers seeking specifications for premix and preformed reinforced plastics will soon find them within the framework of SAE-developed standards.

Increased use of plastic in automotive components lies behind the formation of SAE's new Reinforced Plastics Subcommittee. Currently, the Subcommittee is preparing a guide for users of both premix and preformed reinforced plastic parts. Chairman J. G. Coffin of Chevrolet's Engineering Center in Detroit reports that the proposed guide will contain a general information section on terminology, applications, properties, and the significance of properties in addition to specifications for two types of reinforced polyester plastic now in wide use. (Reinforced plastics for automotive tools will *not* be included.)

What Will Specs Cover?

Specifically, the specifications will cover:

(1) *Sisal fiber reinforced polyester premix* — Used by most automotive manufacturers for heating, ventilating, and air conditioning duct-work and housings.

(2) *Preformed glass fiber reinforced polyester plastic* — Used for major body panels, reinforcements, and semi-structural components requiring higher strength than premix compositions afford.

According to Chairman Coffin: "The applications of both materials have increased substantially since their advent. However, there are still no standard specifications or other simple means of describing them. As a result, companies are often forced to rely on performance tests (possibly supplemented by certain physical and mechanical properties) to control the type of reinforced plastic parts they wish to buy.

New Number System Proposed

"While performance requirements may continue to be specified in critical applications, *many parts can be engineered, purchased, and their quality controlled by means of an SAE number covering certain basic and broadly used types and grades of reinforced plastic.*

"Although the Society of the Plastics Industry has compiled a classification system for all plastics including reinforced types, the Subcommittee unanimously feels that the compositions to date and likely to be needed in the future for automotive applications have not been covered by SPI or any other group.

"Many designers who could make use of certain inherent properties of reinforced plastic are reluctant to do so because of unfamiliarity attributable to insufficient information.

"Under some conditions, substantial economies can be realized by replacement of stampings, die castings, and even some paper parts with reinforced plastic premix. In the case of higher strength preformed reinforced plastic compositions, tool expenditure savings can more than offset the added piece costs (compared with steel stampings) in certain volume situations."

"We now need information on reinforced plastics similar to that which has simplified selection and specification of other commonly used nonmetallic materials."

Refrigerant Development Affects Revised Spec

ADVANCES in passenger compartment cooling systems are evident in the recent revision of the SAE Recommended Practice, Safety Practices for Mechanical Vapor Compression Refrigeration Equipment or Systems Used to Cool Passenger Compartment of Motor Vehicles.

Recognition of potential refrigerant developments led members of the Motor Vehicle Air Conditioning Committee to delete recommendations of specific refrigerant types. Instead, provision is made to permit use of any refrigerant that meets basic non-toxic, nonflammable, and non-explosive requirements.

In addition, the ultimate burst pressure has been reduced from three times the blow-off pressure to two and a half. The latter is more in line with present equipment capacities according to committee members.

Standard for Power Transmission Chains Nears Completion

The final draft of a standard for power transmission chains was completed at a recent meeting of ASA's Subcommittee B 29.10 at Fort Belvoir, Va. The standard covers chains which are designed to withstand overloads without serious damage. Its broad application will result in the reduction of industry and military inventories. Shown above are J. F. Smith, Union Chain & Mfg. Co.; P. J. Imse, Chain-Belt Co.; Subcommittee Chairman B. L. Pearch, Link-Belt Co.; W. E. Land, U. S. Army Engineer Research & Development Labs.; G. W. Haaff, Link-Belt Co.; A. W. Lemmon, Jeffrey Mfg. Co.; and E. L. Harris, Chain-Belt Co.

Nuclear Standards Pursued by ASA and ISO

STANDARDS for the nuclear energy industry are being vigorously pursued by the American Standards Board and the International Organization for Standards, according to Dr. C. R. Russell, SAE representative on the ASA Nuclear Standards Board.

Interest in standardization stems from a desire to do two things:

- Reduce equipment costs.
- Establish confidence in the nuclear energy industry.

In a report to the SAE Nuclear Advisory Committee, Dr. Russel said: "Each instrument and component of the nuclear reactors built to date has, in general, been designed and developed as a special item with few opportunities for the savings which can be obtained through multiple manufacturing. Since the nuclear energy industry is reaching the stage of competitive power costs much more rapidly than anticipated or realized by many people, these additional savings through standardization are of great importance."

Truck Riding Comfort Object of SAE Survey

RIDING comfort in trucks is being explored by SAE's Riding Comfort Research Committee as the result of a joint AMA-ATA request. Technical Board approval of the undertaking came at a recent Board meeting.

As RCRC Chairman A. C. Bodeau of Ford's Engineering Research and Product Study Department sees it, there is a need for ——

- An index of vehicle ride roughness plotted against yearly models.
- A comparison of vehicle ride roughness indices with and without comfort components.
- Comfort plotted against ride vibration frequencies.

Two New Groups Set Up

To carry out this work, the RCRC has created two new subcommittees. The *Instrumentation Subcommittee* hopes to create instrumentation that can be attached to a truck or to the driver himself. This instrumentation would gather ride information for a given truck on a given route.

Specifications for the instrumentation will be based on two factors:

(1) Driver response.

(2) Vibration present in a truck.

However, before developing specifications and selecting instrumentation,

Continued on next page

Charles M. Dean, Pratt & Whitney Aircraft, (left) turns over the chairmanship of SAE's Ignition Research Committee to Franz A. Kneidl, Lycoming Division. Mr. Dean, who has been chairman since 1956, is shown outlining the operations of the new Ordnance and Industrial Engines Subgroup which is currently developing technical recommendations for the Military Services.

Shown at a Nonmetallic Materials Committee meeting are Chairman J. T. O'Reilly, Ford Motor Co., (left) and Technical Board Sponsor C. F. Arnold, Cadillac Motor Car Division, GMC. Among the group's projects is one for developing specifications and test methods for both alcohols and ethylene glycols used as engine coolants. (Story on the Committee's work in the plastics area is on opposite page.)

At a recent Body Engineering Committee meeting, Chairman John Widman, Ford Motor Co., (left) and Vice Chairman D. J. Schrum, Studebaker-Packard Corp., turned their attention to the future activity of a new subcommittee on die model standards. The group expects to develop tolerances for dimensional stability of die model materials.

New System for Typing Elastomers Based on Hot Air Aging

THE new ASTM-SAE system for typing and classing elastomer compounds is based on the following: All elastomer *types* will be determined by hot air aging tests. All basic *classes* will reflect volume of swell in oil.

Using the new format currently under development by the SAE-ASTM Technical Committee on Automotive Rubber, elastomer *types* will be based on the following maximum allowable changes:

Tensile strength plus or minus 30%.

Elongation minus 40%

Shore hardness plus or minus 15%.

Swell tests for determination of elastomer *classes* will require the use of ASTM oil No. 3 at 302 F. The values for volume increase shall be:

Natural rubber, SBR and butyl rubber — no specification.

Neoprene — plus 35 to plus 75%.

Hypalon — plus 76 to plus 150%.

Nitrile rubber — plus 16 to plus 35%.

Polysulfide rubber — plus 7 to plus 15%.

Polyacrylates — plus 16 to plus 35%.

Silicones — plus 35 to plus 75%.

Vinton — 0 to plus 6%.

Formerly, elastomer types were specificed as follows:

Type R — Compounds made from natural rubber, reclaimed rubber, synthetic rubber, or rubber-like materials, alone or in combination, for services where specific resistance to the action of petroleum base fluids is *not* required.

Type S — Compounds made from synthetic rubber or rubber-like materials for services where specific resistance to the action of petroleum base fluids *is* required.

Type T — Compounds made from synthetic rubber or rubber-like materials for services where specific resistance to the effects of prolonged exposure to abnormal temperatures or compounded petroleum oils, or both, is required.

The former class system indicated resistance to low aniline point oils, oils at high or low temperatures, or dry heat.

The Technical Committee on Automotive Rubber is also working in other areas. Tear resistance, compression set, impact testing, automotive sponge comprise other areas of their endeavor.

Truck Riding Comfort

. . . continued from pp. 101.

members will determine what instruments should be used to measure such variables as frequency ranges and acceleration jerk. Location of transducers will also be studied.

The *Measurement Specifications Subcommittee* expects to survey human engineering and truck ride literature in addition to developing measurement specifications.

5 New ARP'S, 2 New AS's Released by SAE

FIVE new Aeronautical Recommended Practices and two new Aeronautical Standards have been released by SAE. They are available in loose-leaf form or separately.

ARP 426 — Compass System Installations

ARP 432 — Tachometer Instruments (Indicator & Generator)

AS 567 — General Practices for Use of Lock Wire, Key Washers, and Cotter Pins

ARP — Silver and Copper Alloy Brazed Joints for Aircraft Powerplants

ARP 575 — Procedure and Method Evaluation of Filter Patch Testing for Aircraft Hydraulic Pumps

ARP 594 — Fuel Booster Pump Design Provisions for Autogenous and Sparks Ignition Prevention and Control

ARP 595 — Aircraft Variable Delivery Hydraulic Pumps

Boden to Receive '58 Manly Medal

Robert H. Boden

MANLY Memorial Medalist for 1958 is Dr. Robert H. Boden, specialist on ion propulsion, and currently program engineer on ion rocket research activity of North American Aviation's Rocketdyne Division.

Boden has been cited for his paper on "The Ion Rocket Engine," which deals with significant design parameters of an ion-propellant rocket engine in terms of three independent parameters. These are: the ratio of the acceleration voltage to atomic or molecular weight of the propellant; gross weight of the vehicle; and thrust-to-weight ratio. Engineering trends are presented which will lead toward advanced study of ion thrust chambers, power generation systems, and propellants. The paper was originally presented on April 9, 1958, at the SAE National Aeronautic Meeting in New York City.

An 8-year veteran of North American Aviation, Boden first worked in the company's Aero Physics Laboratory as a consultant to the chief of research. He participated in early work on combustion vibration, igniters, controls, and instrumentation of rocket engines, and served temporarily as supervisor of the Chemistry Laboratory.

In 1954, Boden was appointed consultant to Rocketdyne's engineering development group. He made original proposals to utilize electronic computing in the analysis of complex engineering data obtained during rocket engine testing programs, organized the first numerical analysis groups, and directed installation of the system at Rocketdyne. From 1956 through 1958 he was staff consultant to the chief of advanced study.

The Manly Memorial Medal is presented annually to the author of the best SAE paper relating to theory or practice in the design or construction of, or research on, aeronautical powerplants or their parts or accessories.

Presentation of the medal will be made April 2 during the SAE National Aeronautic Meeting in New York City. G. N. Cole, chairman of the Manly Memorial Medal Board of Award will make the presentation. Boden's paper will appear in full in 1959 SAE Transactions.

SAE National Meetings

- **June 14-19**

  Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

- **August 10-13**

  International West Coast Meeting, Hotel Georgia, Vancouver, B. C., Canada

- **September 14-17**

  National Farm, Construction, and Industrial Machinery Meeting (including production forum and engineering display), Milwaukee Auditorium, Milwaukee, Wis.

- **October 5-10**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 26-28**

  National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- **October 27-28**

  National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- **October 28-30**

  National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

Dues Deductible Now in Great Britain

SAE DUES are now deductible from income taxes in Great Britain, according to a notice just received by SAE members in Great Britain from SAE headquarters. (Dues have always been deductible in the United States and Canada.)

SAE "has been approved by the Commissioners of Inland Revenue for the purposes of Section 16, Finance Act, 1958," the notice from headquarters informed members in Great Britain, continuing:

"Accordingly, the full amount of your annual dues paid to SAE is allowable as a deduction from your emoluments assessable to income tax under Schedule E, commencing with the year to 5 April, 1959."

SAE TECHNICAL COMMITTEES last year produced . . .

- 257 approved technical standards, recommended practices and reports.
- 129 specific technical recommendations to Government agencies, aimed at improving the usability of Government technical documents by industry.
- In addition, 37 current standards are referred to by regulatory agencies of State or Federal Governments. Last year, too, the CAA referred to 9 SAE Aeronautical Standards in CAA Technical Standards Orders.

Turbine Blade and Vane Castings Can Be Inspected with Radioisotopes

A feature of the SAE Nuclear Energy Advisory Committee

Reported by

T. F. Nagey, Member, SAE Nuclear Energy Advisory Committee

CORE shift and casting flaws in hollow turbine blades and vanes are being detected by a new radioisotopic inspection method recently developed by the Allison Research Department, in conjunction with the GM Research Staff.

The new method should have many other quality control applications as well . . . particularly of products having passages or configurations too small or too intricate for ordinary inspection methods to measure.

Measuring Blade Wall Thickness

Wall thickness could not be measured by standard gages because the heat-exchanger design incorporated in the blades and vanes prevented the insertion of the gages. Ordinary X-ray inspection likewise proved impossible.

With the inaccessible interior filled with a liquid containing the radioisotope samarium 153, however, the 0.020-in. walls can be measured to within ±0.001 in.

Samarium 153, with its high solubility in HC1, was selected to do the job because:

- Its gamma rays are easily attenuated.
- It meets critical requirements for decontamination properties, chemical stability, and physical handling qualities.

The measuring process involves three crucial steps:

- Filling the blade without contaminating the outside.
- Filling the blade completely so that air is not trapped in the heat-exchanger area.
- Avoiding leaks of the samarium solution.

Blades and vanes are now sealed with double-edged adhesive. (Earlier, blade ends had been sealed with an asbestos-base plastic compound, but these had proved hard to decontaminate.)

Trapped air is avoided by the use of a good wetting agent.

Contamination of the outside is prevented by using careful handling and filling techniques inside a glove box.

The filled blade is clamped in a precision fixture containing shielded and properly collimated geiger tubes that measure the gamma rays at predetermined inspection points. Readings at differential airfoil cross-sections have to be normalized to correct for varying volumes of liquid in the blades. This is accomplished by establishing a transmission curve for the casting material, using varying metal thicknesses and a finite quantity of isotope under constant geometry.

States Tackle Regulation Of Atomic Energy Industry

Based on report by **E. Blythe Stason,** Dean, University of Michigan Law School

(To the SAE Nuclear Energy Advisory Committee)

EVER since 1954 — when Congress authorized the development of atomic energy by private industry — but particularly in the past year, the various states have been groping for suitable regulations and machinery. To date, accomplishments are as follows:

1. 14 states have done nothing.
2. 13 states have created official groups to try to chart the future. For example, Michigan has set up a State Advisory Council to advise the governor on atomic energy. A bill that was turned down by the 1958 legislature has been modified for resubmission in 1959.
3. In six states the Department of Health has taken upon itself the responsibility of enforcing health and safety codes based upon its general regulator power.
4. Without specific statutory authority, rules have been adopted by more than one department in eight states. In New York State, the Department of Labor and the Department of Sanitation and Public Health have done this. New York City has a third code.
5. 12 states have adopted a statue setting up a coordinator who contacts other states and the federal agencies. The coordinator has no administrative authority, but he does collect statistics, transmits ideas to industry, and issues development reports. The New England Commission recommended this scheme.
6. In seven states the Department of Health has been authorized by statutes to adopt comprehensive health and safety regulations and to establish a registration system. This scheme will be successful where there is a strong Department of Health and weak vested interests in labor, industry, and public utilities.
7. One state — California — has directed the Department of Health and the Department of Labor and Industry to set up regulations.

A review of this situation indicates that the following essentials should be considered in developing regulations at the state level:

1. Atomic energy should take its place in the economy in the same way that any other industry does. The only exceptions should be based specifically on some peculiar characteristic of the atom. For instance, it may be necessary to increase the standard 2–3-year statute of limitations in radiation health damage cases, since often the damages do not emerge for 10–15 years.

2. The need to prepare regulations to protect health and safety. Such matters as normal dosage, monitoring areas in and around plants, and limits on the rate of discharge into streams and the atmosphere must be deline-

ated. One way to solve the problem might be for the states simply to take over the federal regulations.

3. Establishment of enforcement machinery to see that the regulations are carried out. In Michigan alone there are about 32 industrial concerns using isotopes, 2000 X-ray machines, one research reactor, and one large power reactor.

4. Establishment of a coordinator in the state government who knows about existing practices and advancements and who can encourage the development of the industry in the state. The coordinator would also correlate the activities of his state with those of the other states.

Reference Material

A very helpful bulletin has been published by the National Committee on Radiation Protection.

In addition, a new book, "Atoms and the Law," prepared by the faculty of the University of Michigan Law School will soon be published. It covers negligence, liability, and manufacturers' product liability.

Effect of Radiation on Lubricants Bibliography

Compiled by

DR. CLAYTON R. LEWIS

chairman, SAE Nuclear Energy Advisory Committee

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Users Can Better Air Brake Maintenance

Based on paper by

C. ROY HERRING

Sealco Air Brakes, Inc.

MANY things can be done to eliminate sludge, varnish, dirt, and dust from brake system lines and valves. And, to the extent that such preventive measures can be made successful, the maintenance-free operation of the system will be prolonged.

Here are a few measures to help toward that end:

1. A program of manually throwing the trailer valve into emergency at least once a day will cause movement of all parts of the automatic portions of these valves. These valves and the breakaway kit are among the automatic devices particularly sensitive to standing in one position too long. All breakaway kits have a manual dash control through which the emergency features of the trailer valve can be actuated. The more these parts are moved, the less apt they are to become inoperable.

2. Blowing out the airlines will go a long way toward preventing line freeze-ups in winter weather. (Some fleets install clean-out tees at valves. Then, a plug is removed, an application made of the brakes, and the accumulated moisture blows out to atmosphere.)

3. Open gladhands should be protected, either with dummy couplings or some other device, when a tractor-trailer combination is being uncoupled. Any grease or mud in these gladhands may be forced into trailer air valves when the units are coupled.

4. As regards balance, the service department should try to keep the brakes of all vehicles in the fleet comparable with any new equipment purchased. In the normal processes of maintenance, the braking ability of a fleet may be improved almost in direct parallel with improvements in product by brake equipment manufacturers.

5. Uniform adjustment is a primary requisite to assure brake balance. Unless equal brake lining-to-drum clearance is provided for all brakes on the vehicle, all other design and service effort is nullified. (Brake application time maye be increased by as much as 50% merely by allowing the equipment to run with slack brakes.)

6. For satisfactory air pressure delivery to the brakes, all valves should be as low in opening pressure requirements as is practical — since snubbing pressures are of relatively low poundage. Otherwise the braking chore is unevenly distributed.

7. The ratio of brake-chamber capacity to reservoir capacity should not be overlooked. If this ratio on each vehicle of a combination is not comparable, balanced brakes would be difficult.

8. Variations in air pressure delivery can be simply checked by using a "duplex" gage — actually two separate gages in one housing. The indicator hand for each gage uses the same common dial face. Thus, action of the two gages can be watched simultaneously. By connecting one hose of the gage to a tractor brake chamber, the other to a trailer brake chamber, observation can be made of variation in:

- Low-pressure delivery.
- Time of rapid high-pressure delivery.
- Amount of pressure delivered.

The operator then has the option of either speeding up slow axles or slowing down the fast axles. To slow down a fast axle will cost as much in money — and much more in stopping distance — as to speed up the slow one.

To Order Paper No. 20S . . . on which this article is based, see p. 6.

Train for Quality

Based on report by secretary

R. W. HEARL, North American Aviation, Inc.

EMPLOYEES must be trained to produce quality work. Experience has shown that in the majority of cases, on-the-job training has proved more effective than classroom instruction.

It is important that the employees know what quality standard is expected, why it is necessary, how to achieve it, and that quality comes first and production next.

The importance of safe handling, appearance, strength, formability, and ease of assembly should be stressed. These requirements are the *minimum* and in many cases, the engineering drawing, tooling or production orders call for more rigid requirements.

Employees should be taught that good quality is necessary to produce a product that will meet competition in life, performance, and appearance, and that these requirements, in turn, affect each individual's job security.

This information is best brought to the employees attention by supervisors meeting with their leadmen, who in turn work with their groups, instructing them and showing them how the work should be done. It is important that these meetings reveal the employee's part in assuring good quality, why certain methods are better than others, and what the results of substandard work are — such as shorter life of parts, failure causing accidents, and poor appearance resulting in poor customer relations.

Supervision must continually survey their areas looking for conditions which make it difficult for employees to produce quality work, such as congestion, faulty machines, benches, handling equipment or lack of same, and poor practices. Steps must be taken to have these conditions corrected. Supervision is responsible for stating the cause of a rejection and the corrective action to be taken on the rejection or rework tag.

Repetitive rejections should be noted by inspection, and handled by a higher level each time, to assure that everything possible is done to prevent them from occurring again. Any sub-standard work is also shown to the employee or employees who were responsible for it and they are informed why it is not acceptable. This is one of the most important phases of the training program for the employee learns only through his errors.

Serving on the panel which developed the information in this article, in addition to the panel secretary were: **W. V. Gres,** North American Aviation, Inc.; **H. G. Hall,** Douglas Aircraft Co., Inc.; **R. W. Allen,** Solar Aircraft Co.; **A. S. Billings, Sr.,** Ryan Aeronautical Co.; and **W. D. Emmert,** Douglas Aircraft Co., Inc.

This article is based on a secretary's report of a production panel entitled "How to Build Quality." This report — along with 10 other secretaries' reports on various aircraft production subjects — is available in multilith form as **SP-325. See order blank on p. 6.**)

Rating Programs Need Rigid Control

Based on paper by

JOHN VERSACE

Chrysler Corp.

EVERY act of measurement involves a human judgment whether a measurement is called objective or subjective, physical or personal, scientific or unscientific. Some measurements can be reproduced with insignificant disagreement among a number of people and we will probably call these physical measurements. Others, notably ratings, cannot be reproduced very closely, so we generally refer to them as subjective measurements.

There is a limit in the precision with which we will ever be able to match a rating with any other measurement, and that limit is determined by the unreliability or departure from exact reproducibility of the rating. As a result, no exact correspondence between physical measurements and ratings for shake, roughness, thump, and the like, can ever be found, except spuriously.

Still, there is no need for complete demoralization because an imperfect correlation is found between some physical measurements and a rating. The imperfect correlation may not be due to the failure to discover what tire thump, or shake, or comfort really is. The failure may be in not realizing that the criterion for thump or shake is essentially unreliable, and thus no perfect correlation can ever be attained.

We are not bound forever to an unreliable system of evaluation, however, just because a perfect correlation is impossible. For example, there are times when we touch an object and say it is very hot, and at other times that it is very cold, and at still other times when we will give some intermediate assessment. We are talking about a subjective experience of temperature. As might be expected, the reliability of ratings of relative "hotness" is far from perfect, but that did not stop us from making tremendous strides in the study of thermodynamics. Other observations were discovered which covaried with temperature assessments, though with a rather poor correlation. A correlation was noticed between the subjective state of the person and a phenomenon, apparently irrelevant to his subjective state, the height of a mercury column. But once this was one, the use of subjective assessments was abandoned and a law was postulated relating the phenomenon of mercury expansion to temperature.

Rigid Control Essential

The fact that correspondence between sets of measurements can never be any greater than the reliability of making any of these measurements in the first place is not sufficient to stop us from using instrumental correlates, even if the correlation is poor. We should be careful not to reject the usefulness of a system of laboratory measurements just because we do not get exceptionally good agreement between these measurements and some set of on-the-road ratings. Some fundamental measurements for many apparently subjective vehicle characteristics may prove useful. A more important problem for engineers is that of setting up a testing program that will show validly the relation among these variables.

Whether a rating program is for purposes of engineering decision-making or for scientific purposes, it must be rigidly controlled according to the best procedures of experimental design. There must be a deliberately planned sequence of observations in which all irrelevant variables are forced to cancel out or otherwise be accounted for and an estimate of the reliability of the observations is obtained. There is adequate statistical theory, under such conditions, to give numerical specifications of the confidence that is warranted in the results. If this is not done, we will have no idea of the magnitude of the risks of blundering. And, worst of all, we will probably have systematic bias effects that may seriously distort the conclusions.

To Order Paper No. 21S . . . on which this article is based, see p. 6.

Aluminum Alloys and Stainless Steel Withstand Radiation Best

Based on paper by
J. GRAY STUART
Aircraft Nuclear
Propulsion Department
General Electric Co

TABLE 1 — Sensitivity of Engineering Materials to Radiation

Neutrons/cm²	
10^{14}	Germanium Transistor — loss of amplification
	Glass — coloring
10^{15}	Polytetrafluorethylene — loss of tensile strength
	Polymethyl Methacrylate and Cellulosics — loss of tensile strength
	Water and Least Stable Organic Liquids — gassing
10^{16}	Natural and Butyl Rubber — loss of elasticity
10^{17}	Organic Liquids — gassing of most stable ones
	Butyl Rubber — large change, softening
	Polyethylene — loss of tensile strength
10^{18}	Mineral-Filled Phenolic Polymer — loss of tensile strength
	Natural Rubber — large change, hardening
	Hydrocarbon Oils — increase in viscosity
	Metals — most show appreciable increase in yield strength
	Carbon Steel — reduction of notch-impact strength
10^{19}	Polystyrene — loss of tensile strength
10^{20}	Ceramics — reduced thermal conductivity, density, crystallinity
	All Plastics — unusable as structural materials
	Carbon Steels — severe loss of ductility, yield strength doubled
	Carbon Steels — increased fracture-transition temperature
	Stainless Steels — yield strength tripled
10^{21}	Aluminum Alloys — ductility reduced but not greatly impaired
	Stainless Steels — ductility reduced but not greatly impaired

SOME materials withstand the radiation and high temperatures prevailing near nuclear reactors much better than others. Table 1, for instance, indicates the results of irradiating materials that are often used in electronic components. Note that aluminum alloys and stainless steel can stand very high intensity radiation, with ductility not greatly reduced, whereas at much lower intensity the germanium transistor suffers loss of amplification and glass becomes colored.

The more resistant materials can survive the environment in which control equipment for aircraft propulsion reactors will operate. For example, GE has successufily operated a 3-stage preamplifier exposed to 1000 F and a high neutron flux.

Radiation damage varies with the kind, amount, and rate of radiation; the elemental composition and the molecular composition of the material; and the volume of the material subjected to irradiation. The kind of radiation to which the material is subjected affects the extent of damage, but not all classes of materials are damaged by all of the energy transfer processes.

There are three interactions that cause damage:

- Ionization.
- Displacement.
- Transmutation.

The effects of the interactions vary with the make-up of the materials. For instance, ionization reduces the effectiveness of certain resistors in a radiation field, but it does not affect the conductivity of wire appreciably. Displacement of atoms as the result of collision with radiating particles causes materials to become embrittled. Transmutation, which is an actual change in the nucleus of the atom, introduces foreign matter that may change the engineering characteristics of the original material.

To Order Paper No. 2T . . .
on which this article is based, see p. 6.

Dry Ice Gains Favor As Trailer Refrigerant

Based on paper by

ROLLIN F. ALLYNE
General Dynamics Corp.

REFRIGERATION of trailers with dry ice units has been developed to a point where it has many advantages over mechanical methods. Based on the experience of users, these advantages are:

1. Initial investment savings of about 65%.
2. No expensive parts to wear out or break down.
3. Increased revenue with dry freight — about 1200 lb more payload.
4. No tie-up for preventive or unscheduled maintenance.
5. No deterioration with long disuse.
6. Dependability resulting in fewer claims.
7. An operating life of 12 years or longer.
8. Accurate forecasting of operating costs.

The Econo-Cold refrigeration unit illustrated and described in Fig. 1 takes 50-lb blocks of dry ice sealed in a shelved compartment. As the dry ice sublimes by conduction, the block is reduced in height, but its area contact with the metal shelf, through which the heat reaches it, remains relatively constant. Dry ice requirements for a given job, depending on trailer length, insulation thickness, temperature to be maintained, and outdoor conditions, can be predetermined. By the same token the refrigeration costs for a hauling job can be known in advance.

To Order Paper No. 16R . . . on which this article is based, see p. 6.

Fig. 1 — Left end view of Econo-Cold refrigeration unit with compartment door open to show shelves for dry ice. (Right) control box containing thermostat. Upright heat exchanger is made of welded aluminum and has wavy fins on both sides (not shown) to provide added heat transfer surface. Exchanger is boxed in so that fins form vertical flues between trailer nose and bulkhead through which fans draw air from floor level. Discharge of air at ceiling level and return of air at floor level gives wrap-around circulation.

Progress Report on "Exotic" Materials

Based on report by secretary

H. B. SIPPLE
Lockheed Aircraft Corp.

SO-called "exotic" materials are finding increased application in the aircraft and missile industry. Here are some data on four of these materials.

Rene 41 — Rene 41 is a nickel-base alloy for use in the temperature range of 1200–1800F. In the annealed condition, it has an ultimate tensile strength of 165 ksi maximum, yield strength of 100 ksi maximum, and elongation of 35% minimum.

After aging, its elevated temperature tensile strength and creep rupture properties are among the highest of the nickel-base super alloys. This alloy is weldable and forms similarly to stainless steels. However, the formability is not quite as good as the precipitation hardening stainless steels.

Haynes Stellite No. 25 — H.S. 25 is a cobalt-base alloy with potential application for sheet metal airframe parts subject to temperatures as high as 1800F. Properties in annealed (solution heat-treated) condition are ultimate, 160–200 ksi; yield, 80–160 ksi; and elongation 20–60%. This material is weldable and has good ductility. Formed parts may require interstage anneals to remove work hardening. Solution's heat-treat scale is best removed by molten caustic baths.

Molybdenum — Commercially pure molybdenum as well as the ½% titanium alloy will find application in airframes where temperatures are above 1800F are encountered. Its principal advantage is its high strength at high temperature. Its principal disadvantage is its poor oxidation resistance.

Molybdenum can be sawed, sheared, punched, or slit using conventional equipment. However, the brittle transition temperature for molybdenum is greater than room temperature, consequently forming must be done at elevated temperatures and except for very thin gages, shearing should be done warm or hot. 300–400F is recommended for shearing 0.010–0.020 in. sheet while 900–1475F is recommended for shearing gages over 0.040 in. 400–600F is recommended for bending and 600–1000F for hydroforming or deep drawing.

Niobium (Columbium) — Columbium is a high-temperature metal in the same category as molybdenum. Unlike molybdenum, columbium's brittle transition temperature is well below room temperature even after heating above the recrystallization temperature. The metal does not have elevated temperature strength comparable to molybdenum. However, it is ductile and can be formed at room temperature by conventional forming methods. Commercially pure metal has an ultimate strength of 39,000 psi, yield of 24,000 psi, and elongation of 20–30%, while the ½% zirconium alloy has an ultimate strength of 42,000–60,000 psi, yield of 24,000–54,000 psi and elongation of 8–17%. Columbium, like molybdenum, is subject to oxidation. Thus, vacuum, argon, or helium atmospheres will be required where stress relieving is employed. Also coatings will be required for service at elevated temperature.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: **G. W. Papen,** Lockheed Aircraft Corp.; **B. Gaiennie,** Northrop Aircraft, Inc.;

John S. Welty, Solar Aircraft Co.; **Leo Schapiro**, Douglas Aircraft Co.; **M. C. Copold**, General Dynamics Corp.; **W. A. Mays**, North American Aviation, Inc.; and **M. H. Binstock**, Atomics International.

(This article is based on a secretary's report of a production panel entitled "Exotic Materials and Processes." This report — along with 10 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-325. See order blank on p. 6.)

Bubble Canopies Pose Major Problems

Based on talk by

J. D. RYAN
Libby-Owens-Ford Glass Co.

(Presented before SAE Detroit Section)

A NUMBER of serious obstacles must be overcome before bubble canopies can be used on production automobiles. This is true whether transparent plastic or glass is the material used.

All known plastics lack abrasion resistance, although suitable for aircraft, and they tend to craze and crack very quickly under load. They cannot be used for windshields because the action of the wiper quickly renders the glazing unusable, while without lamination they break into sharp edged fragments similar to plate glass.

The development of glass canopies is hindered by the problem of shaping. Plastic bubble canopies can be formed in the temperature range of 250–400 F, whereas glass will require ranges in the region of 1200–1500 F, which only compounds difficulties.

Only laminated glass would seem capable of serving as a roof structure. Tempered glass would be unsatisfactory (it cannot now be used in windshields), so manufacture is further complicated by the need to form two lights of glass with sufficient precision to permit later joining with a plastic interlayer. Laminated plastic canopies are formed, of course, with the same tooling and techniques used for making monolithic canopies. On the other hand, glass laminates cannot be postformed since no plastic material is sufficiently stable to withstand the temperature necessary for shaping laminates to bubble canopy configurations.

To be successful as a transparent roof enclosure, a glass bubble canopy would have to be made with annealed glass and adequate strength built into it by using heavy plastic interlayers and greater glass thicknesses than normally employed now. Such increases in thickness would impose a weight penalty and add to cost.

Assuming a successful technique for making laminated glass canopies, there still remains the problem of watertight mounting created by the wide difference in the coefficient of expansion of glass and metal. There would also be optical problems.

There would be an uncomfortably large influx of solar radiation through a canopy top glazing. To prevent its entrance to the passenger compartment it would have to be absorbed, or reflected, or a combination of both. Reflecting would be better than absorption; it would minimize heating effects. It is to be hoped that a film can be produced for application to the outside of the glazing to reflect selectively the infrared and untraviolet portions but not reflect too much light in the visible region. A filmed glazing which reflects 20 or 30% of visible light could be annoying, and hazardous to motorists who happen to meet such mirror-like glazings.

Better Controls To Mark Car of 1980

Based on paper by

J. B. BIDWELL
General Motors Corp.

MAJOR revolutionary changes seen in the cars of 1980 will come about through increased attention to driver-vehicle-highway relations. These will include new types of driver control elements and simplified instrumentation.

Reduced high-speed aerodynamic power requirements may be expected in the future and with it a reduction in fuel consumption. Wind resistance of the present passenger car could be cut almost in half without serious sacrifice of space utilization.

Currently, the gas turbine is attracting attention. In the regenerative form it can be made comparable to piston engines in size and weight, but it still suffers a fuel economy disadvantage. This characteristic, coupled with poorer transient response, makes it unlikely that the turbine will replace piston engines by 1980.

Recent progress in vehicle dynamics studies is certain to influence future models strongly. For example, in the past few years the lateral control problem has yielded to analysis and it is now possible to predict accurately the dynamic directional response of a vehicle to both driver commands and external disturbances.

Instrument readings will be minimized or replaced by other types of signals. Examples of this sort of development are the recently introduced audible overspeed signal and the replacement of meters by indicator lights. Another potential use of hearing which would further relieve the driver's overloaded vision is the provision of audible road information in the car by some means such as induction radio. Automatic guidance or some audible path error system might reduce fatalities caused by cars leaving the road. One means would be to have a servo power steering equipment position the front wheels in response to a command from a small computer. Path error is detected by tuned coils sensing a magnetic field produced by a current-carrying wire in the road.

To Order Paper No. 12S . . .
on which this article is based, see p. 6.

What's Ahead For Bus Design

Based on paper by

E. N. HATCH
Director of Franchises, Nassau County, N. Y.

(Presented before SAE Philadelphia Section)

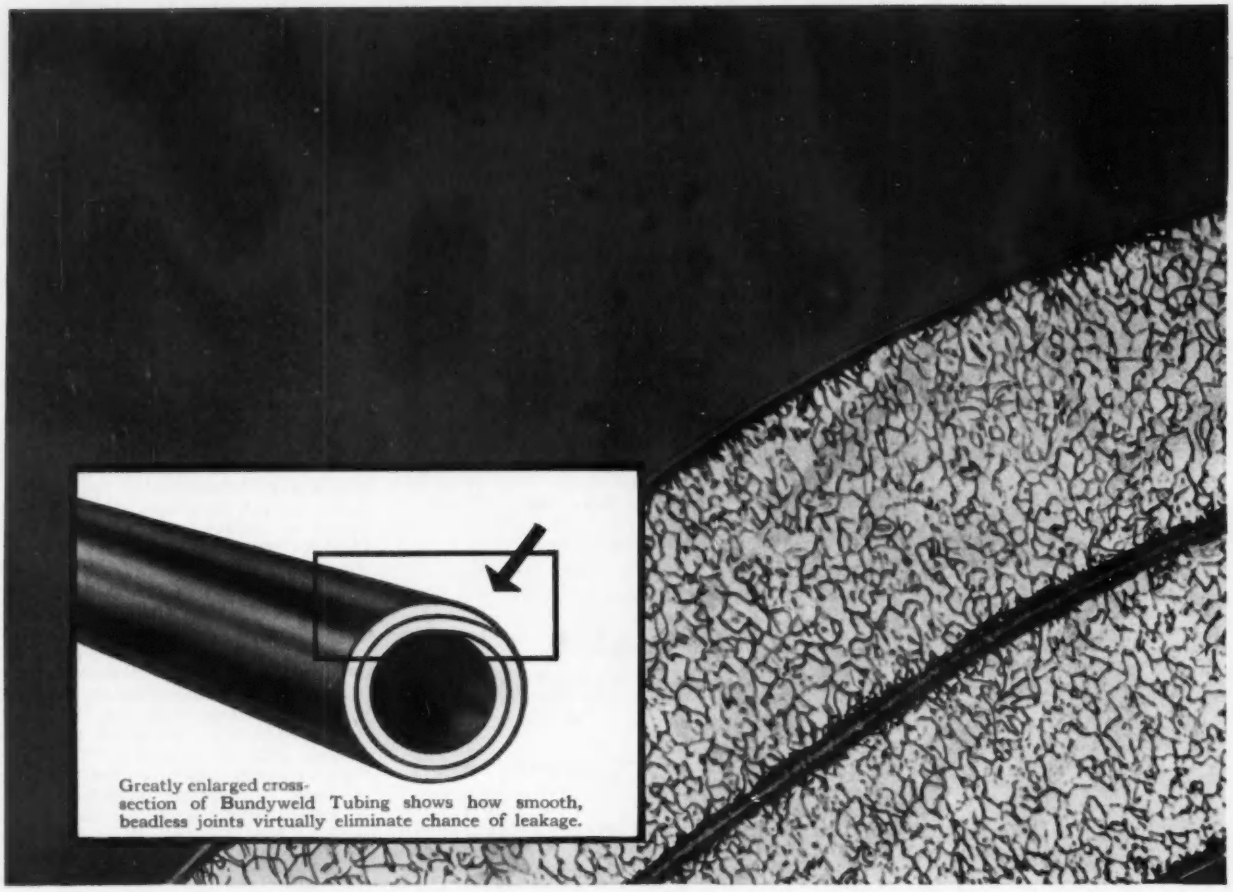
THE gas turbine is the coming powerplant for buses. It will be introduced to reduce weight, increase power, and lower maintenance. It is unlikely to appear in the next few years, but it would be no surprise to find it in use five to ten years hence.

The gas turbine has great promise despite the efficiency and good design of today's diesel engine. It is much lighter and smaller than the gasoline or diesel engine of the same horsepower. Since it is aircooled it would banish one of the major maintenance problems of liquid-cooled engines. It is simple in design and has far fewer moving and wearing parts.

Automatic transmissions will be adopted more widely. Granted the efficiency of the individual automatic transmission is less than that of the gearbox, in a type of operation involving a lot of stops, the miles per gallon of fuel have been nearly doubled with the automatic transmission. Individual unit efficiency is not the governing factor; it is the overall efficiency that is the final answer. This is another indication why the supposedly less thermally efficient gas turbine may prove to be a more efficient powerplant in a bus. Much work and

Continued on page 112

WHY BUNDY LEADS IN MASS-FABRICATION:



Greatly enlarged cross-section of Bundyweld Tubing shows how smooth, beadless joints virtually eliminate chance of leakage.

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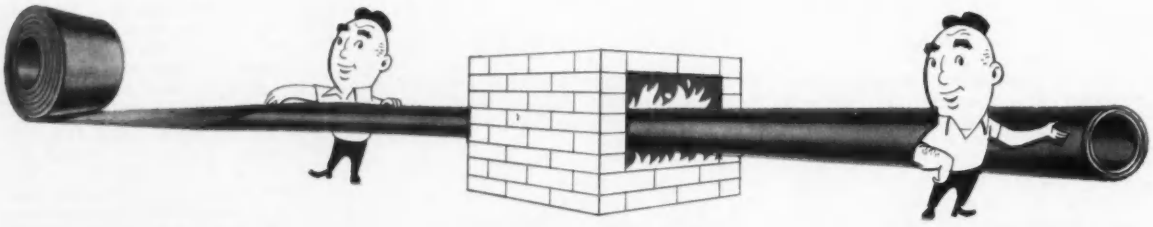

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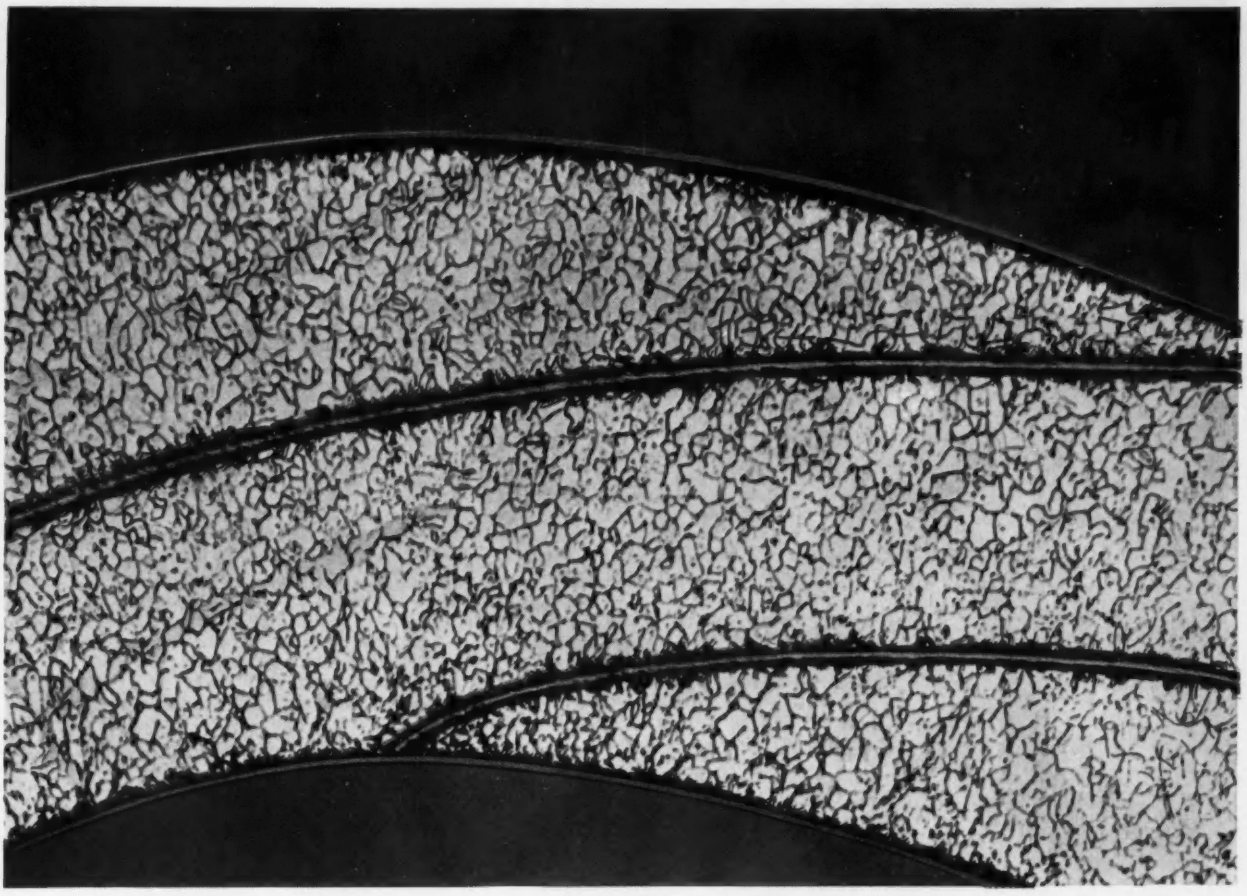

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Continued from page 109

testing are needed to prove or disprove this point.

Power steering may prove necessary on the larger buses as our experience with 40-ft buses shows. In this instance, two problems dictated the use of power steering. One was to be able to turn the front wheels so that the 40-ft bus could turn street corners over which a 35-ft bus had been operating. The second problem was to get drivers willing to operate the new bigger buses. The only inducement was to make the job physically easier and power steering did it. Bus size is therefore, a deciding factor.

What About Air Conditioning?

Air temperature in any particular area will decide whether or not to air-condition buses. For cross-country service air conditioning is a must, but its value is questionable in city operation where stops and starts are 5–10 to the mile and doors are open a large part of the time, particularly in northern cities. The southern cities have a different problem.

The size of buses depends on specific operating conditions. A general rule governing the selection of bus size seems to be this: If the operator can save one bus out of ten without the necessity of increasing headways too much, the larger type of bus should be considered. In recent years economics has favored the big bus.

To Order Paper No. S139 . . . on which this article is based, see p. 6.

What the Well-Designed Transmission Fluid Needs

Based on paper by

A. J. BOZZELLI
Sun Oil Co.

RECENT laboratory tests of the various performance properties of an automatic transmission fluid show that:

- A V.I. improver representative of the intermediate molecular weight range provides optimum properties of low-temperature fluidity and shear stability.
- The base oil should be largely of the high V.I., oxidation stable, Mid-continent variety. Proper dewaxing and the use of pour depressants are desirable to aid low-temperature fluidity.
- To meet rubber swell requirements, the fluid should contain a seal swelling component. A judicious choice is a well-refined oxidation stable naphthenic stock.
- There should be closer cooperation between transmission manufacturers, seal suppliers, and fluid suppliers to develop (1) a significant test procedure for evaluating seal shrink, and (2) a truly standard seal compound.
- Choice of detergent-inhibitor materials for a fluid can have profound effect on fluid performance.
- Inhibition of the fluid not only affects total fluid life, but also the antisquawk life. Data were presented to substantiate this belief.

To Order Paper No. 13T . . . on which this article is based, see p. 6.

Prime Contractor Bears Heavy Load in Weapons Systems Concept

Based on report by secretary

J. C. CONDON
North American Aviation, Inc.

PROCUREMENT in support of a weapon system differs from the conventional approach in that responsibility for the entire finished product rests with the prime contractor.

As practiced by the Air Force, the weapon system approach involves the prime contractor and the Weapon System Project Office in a management partnership. The WSPO acts as a single point of Air Force contact for program decisions and coordination with the technical, procurement, and using commands.

In place of the conventional concept of somewhat detailed requirements, WSPO defines Air Force needs by providing only general operating requirements and military characteristics of a system. Subject to Air Force approval, the prime contractor establishes the design concept; selects and manages the subsystems suppliers; establishes tests, procedures, and programs for company furnished equipment; conducts the developmental flight test program; and develops and produces an integrated weapon system for delivery to the Service.

This concept necessarily results in a much larger percentage of systems and subsystems procurement. Design of the major systems and subsystems is generally provided by selected sources on the basis of performance specifications. Either performance or standard procurement specifications define for the supplier the smaller items peculiar to the particular weapon system.

Obviously, this type of procurement requires a thorough precontract screening of potential suppliers. This screening is accomplished through evaluation teams composed of procurement, engineering, financial, manufacturing control, quality control, and industrial engineering members.

Upon selection by the prime contractor (and approval by WSPO) of the most capable source, contracts are

Continued on page 114

STRENGTH AND UNIFORMITY are outstanding characteristics of the automotive ball-joint bearings shown below. These sintered metal parts demonstrate Moraine Products' capabilities in working with customers to develop the most practical designs. They also demonstrate Moraine Products' responsibilities—making economically, and in quantity, parts that must not fail under the most rugged operating conditions.

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Division of General Motors, Dayton, Ohio

negotiated and issued. The administration of these contracts is handled entirely by procurement personnel. All problems affecting the item being procured are coordinated with and transmitted through the prime contractor's procurement people and the supplier's sales office.

Project offices are normally set up by both the prime contractor and the supplier. Members of the prime contractor's project office team include personnel from procurement, management, scheduling, contracts, and quality control. In addition, personnel from technical design, product design, specifications, laboratory and flight test groups, and the representatives who are resident at the supplier's plant, report directly to the project office. Generally, the supplier's project office team is made up of sales, management, engineering, quality control, and the representative who is resident at the prime contractor's plant. The procurement man on the prime contractor's team and the sales contact on the supplier's team are responsible for funneling all information to the proper members within their groups. All information is made a matter of record by correspondence or through use of special forms, thus permitting both project office teams to be aware of the current status of the project.

Under the managerial concept of weapon system procurement close cooperation is required between the prime contractor and the supplier. This is accomplished by the exchange of company representatives on a resident basis and periodic coordination meetings between members of both project teams. Since the managerial partnership concept is handed down, to a lesser degree, to the supplier, it has the effect of delegating more responsibility to the supplier of specialized equipment.

This delegation of responsibility creates a problem in that the prime contractor may not be constantly aware of procurement details or problem areas. This can be solved through the use of periodic coordination meetings and reports of all types. The reports are submitted periodically and cover the technical progress of item development, cost expenditures, manufacturing status, and the like. In addition, this management approach delegates responsibility to the supplier for constant reappraisal of the program with respect to possible redirection of the designed item. This possible realignment could occur if it was apparent that it would substantially reduce cost, advance the state-of-the-art, or permit earlier delivery of the product.

Monitorship over the supplier's operations by the prime contractor permits shorter lines of communication and allows corrective or implementing action to be initiated much more quickly than under the conventional concept of procurement. Many de-

Continued on page 119

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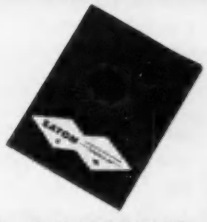

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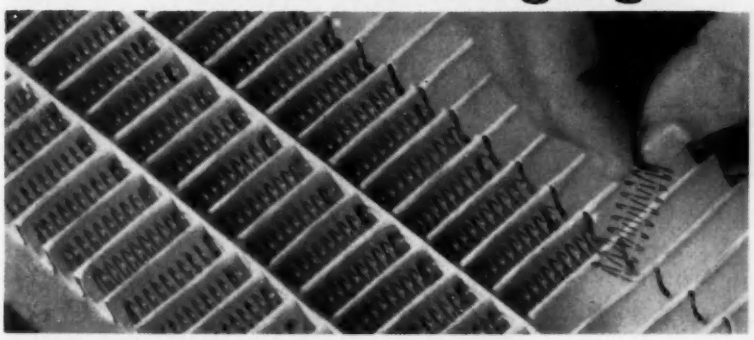

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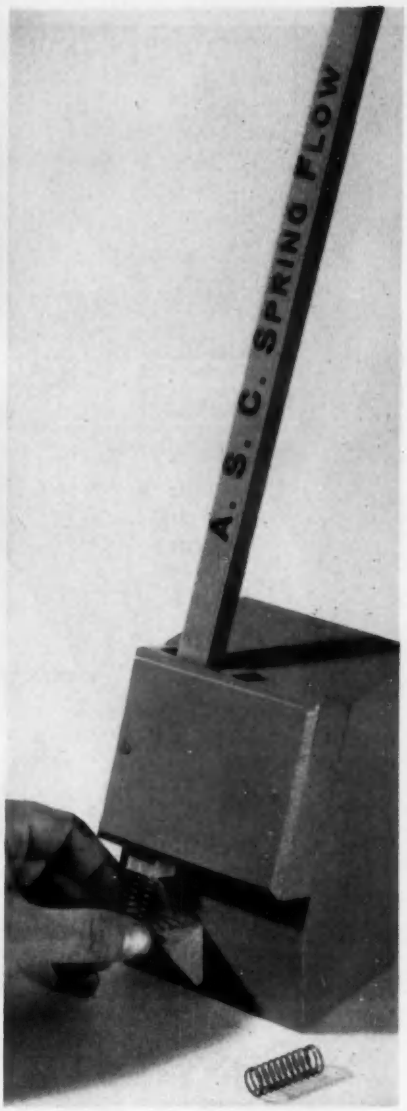

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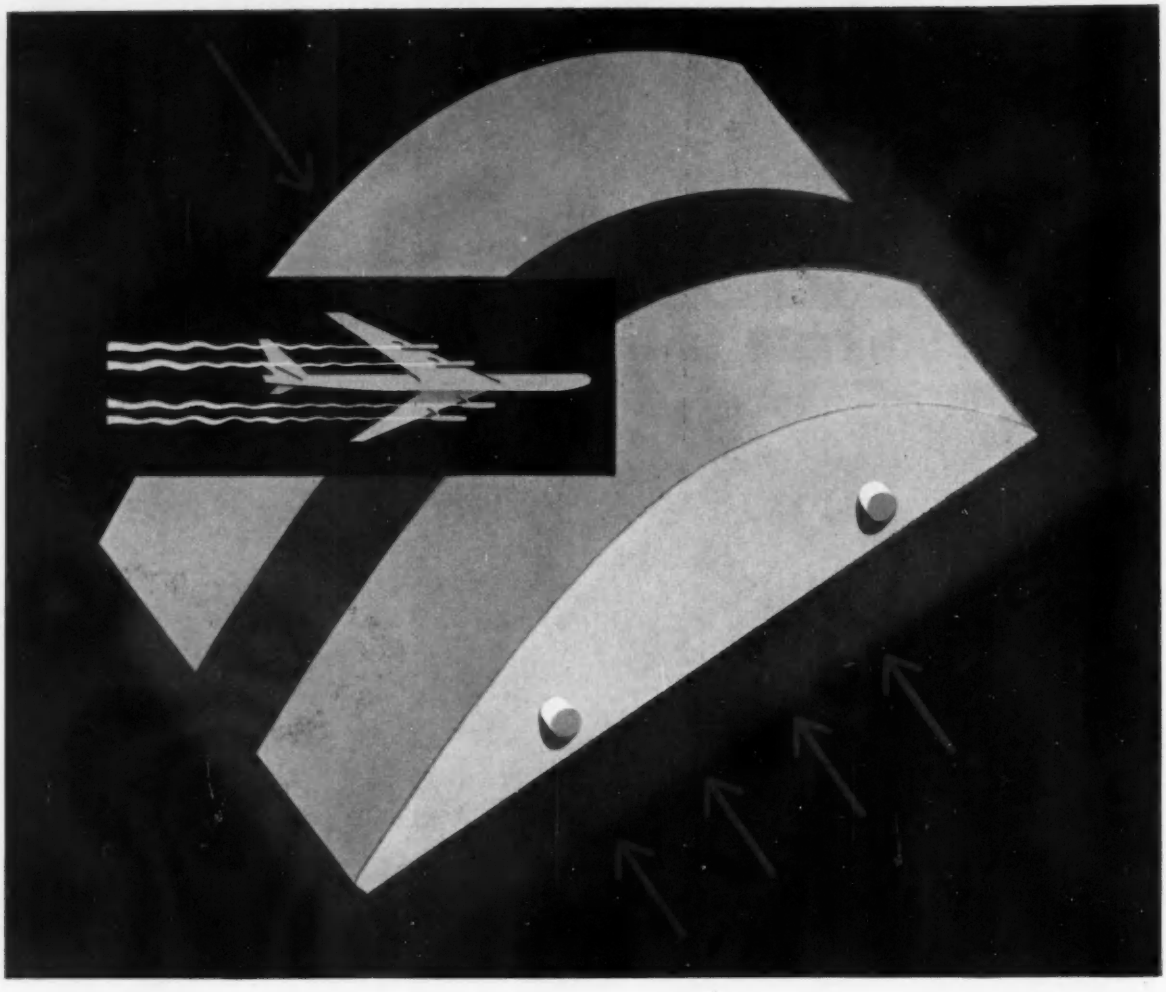

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tailed procedures and reports affecting all phases of the prime contractor-supplier relationship can be and have been developed to, in short, deliver an advanced weapon system in the shortest period of time.

Serving on the panel which developed the information in this article, in addition to the panel secretary were: **Rulon Nagely**, North American Aviation, Inc.; **J. W. Hinchliffe**, Northrop Aircraft, Inc.; **Norval Grigg**, Boeing Airplane Co.; **W. G. Doran**, Douglas Aircraft Co., Inc.; **Robert Kahn**, General Dynamics Corp.; **Denham Scott**, B. Garrett Corp.; and **Barry Shillito**, Hughes Aircraft Co.

How to Get More From Missile Tests

Based on paper by

J. W. LUECHT

Martin Co.

TESTS that report data in a fail or didn't fail manner are a luxury we can no longer afford in tests on ballistic missiles. The tolerance of each part for the next must first be determined if confidence is to be placed on the few flight tests possible with these complex and expensive missiles.

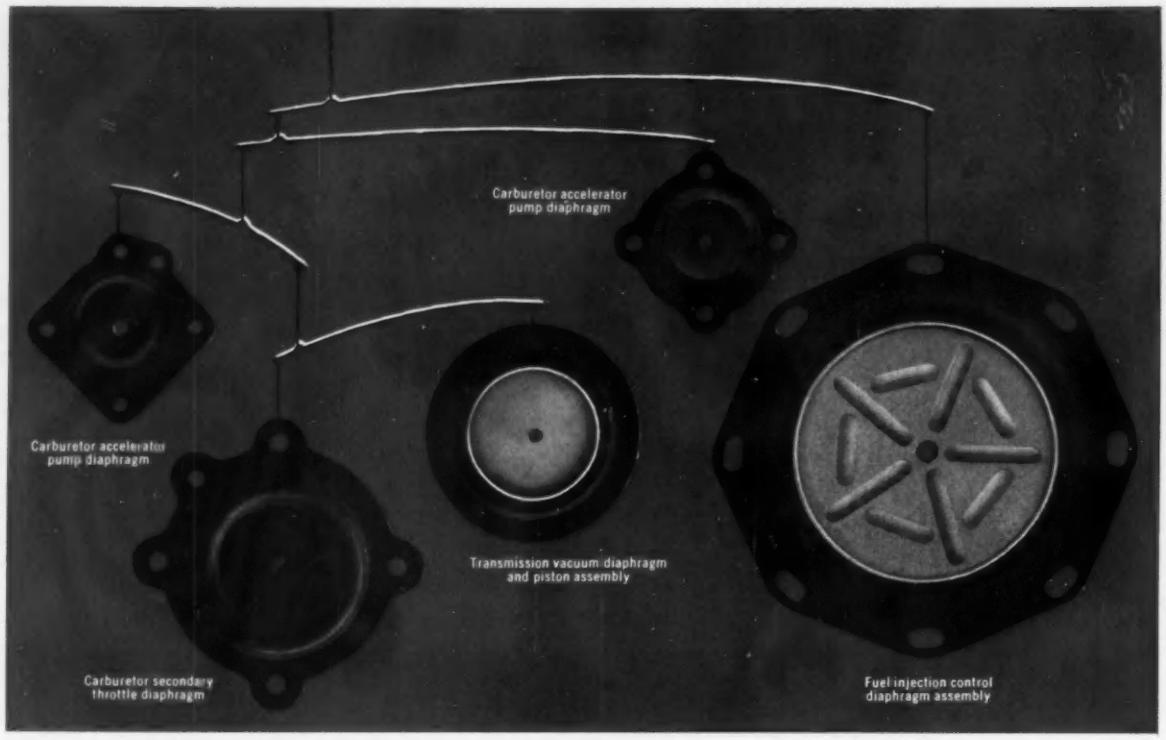
The failure of any systems can always be ascribed to a situation where it is subjected to either a functional or environmental input which it could not acccept and still maintain its proper functional output. Such failures can be kept small if it can be shown that at the interface of two systems the statistical output of one is well within the acceptance limits of the other. This type of data is usually acquired in the laboratory.

Armed with this information a flight test program is set up with a calculated margin of safety between the inputs and outputs of the various systems, and their subsystems. Then, the tests can measure margins of safety by determining:

- The accuracy of the assumed environment and its variations.
- The validity of the calculation of output in terms of input of each system.

As a result, the sample size for confidence will be determined as the flight tests are run. By combining the data on system tolerance and flight test results, it is possible to establish a high order of confidence with a small number of flight tests. This is because the tests will either confirm the environmental and input-output assumptions postulated and tested in the laboratory or point out the weak spots.

To Order Paper No. 5S . . . on which this article is based, see p. 6.



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Briefs of SAE PAPERS

Continued from page 6

ing radius, as well as "tracking" of front and rear wheels; design and operation of equipment used; two methods of balancing wheels.

Nondestructive Testing in Fleet Maintenance, D. P. WALSH. Paper No. 20V. Application of nondestructive tests by means of penetrant methods and magnetic particle inspection for locating cracks before fatigue failure occurs thus preventing failure of parts while in service; details of methods and means; inspection should be scheduled to coincide with other work particularly if disassembly of components is necessary; recommendations made.

History and Theory of Engine Temperature Control, J. A. BELAIRE. Paper No. S132. In temperature tests taken on diesel, gas and LPG engines of automotive and commercial vehicles it was found that use of automatic radiator shutters to control ram air flow through radiator core and into engine compartment were beneficial during high and low ambient weather; jacket water temperature of 180 F is desired and must be maintained uniformly; surface and engine compartment temperature should be maintained at higher levels.

Transition from Cotton to Rayon to Nylon to Steel in Truck Tires, J. M. LARK. Paper No. S133. Development of pneumatic truck tire and various cord materials; improvements made in spinning technology; rayon's role in improving truck tire mileage and advantages of nylon cord; future trends with regard to steel cord tires; advantages and limitations.

Method of Charge Stratification for Four-Stroke-Cycle Spark-Ignition Engines, L. D. CONTA, P. DURBETAKI. Paper No. S134. One method of improving efficiency of spark ignition engine at light load is use of mixture ratio control to effect load variations; charge stratification makes load-control possible; principles involved and details of N. O. BRODERSON's method for producing stratification; results of engine tests carried out at University of Rochester, N. Y., show that method is workable, and that predicted advantages are obtained.

Economics, Research, and Air Conditioning Industry, I. M. PALLEY. Paper No. S135. Discussion of homogeneous reaction kinetics, and afterburner problem of automobile or other

Continued on page 123

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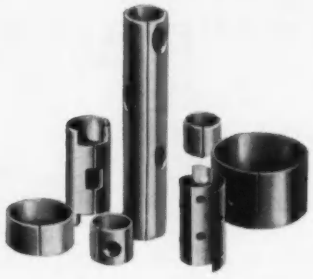

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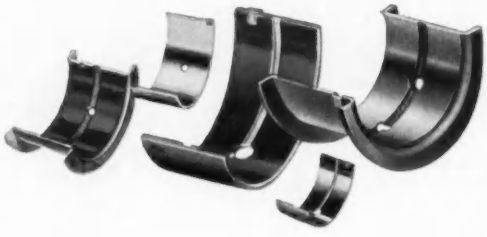

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Briefs of SAE PAPERS

Continued from page 121

internal combustion engines and implications for air conditioning industry with regard to air pollution problem.

Developments in Immediate and Future Bus Transportation, E. H. HATCH. Paper No. S139. Discussion from viewpoint of engineer concerned with specification, purchase, maintenance and operation of city and urban transit buses; available types of power plants, need for different type of engine, and potential of gas turbine; other features; future of bus transportation in cities and urban areas will depend on how cities plan, design, and construct street, highway, expressway and parking areas for buses and private cars.

Torsilastic Springs and Suspensions, J. H. KRAMER. Paper No. S140. "Torsilastic" spring is torsion type spring having inner shaft surrounded by annular layer of rubber and metal shell around outside; parts of spring are: inner shaft, outer shell, and cylinder of rubber bonded to both shaft and shell; design details, characteristics and specific applications for passenger cars and heavy vehicles.

Maintenance and Its Relationship to Fleet Costs in Today's Economy, M. K. SIMKINS. Paper No. S142. Engineering approach to truck fleet operation is proposed involving factors such as vehicle selection, scheduling of maintenance periods, costing and retirement of vehicles, figuring load factors and route efficiencies; responsibilities of maintenance department; reduction in maintenance costs can be achieved by efficient utilization of brain power, personnel, vehicles, shops and tools, records and systems, etc.

Engine Shape and Where to Put It, R. A. DENT. Paper No. S143. Several possible piston type engine configurations are examined to predict future trends; influence of engine displacement on cylinder configuration, and relationship of engine displacement to car weight; size and weight of engine in relation to weight of vehicle have vital effects on car stability, control, and handling characteristics regardless of whether engine is mounted in front or in rear; it seems that V-8 and inline six engines will continue to predominate.

Power Unit for Mechanical Refrigeration, J. M. SMIDL. Paper No. T37. Features of engine generator set, developed for railroad refrigeration serv-

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Briefs of SAE PAPERS

Continued from page 123

ice, supplying power for compressor, condenser fan, evaporator blowers and car heaters; engine is 4 in. bore, 4 in. stroke, diesel rated at 18 hp, 1800 rpm, for continuous duty; it uses 4-stroke cycle with precombustion chambers and pintle type nozzles, which contribute to its preference for No. 2 diesel fuel; fuel and lube oil system; fuel supply and mechanical safety controls; lube oil filtration.

Engine Voltage Requirements Using Spark Plugs Pre-Ionized with Radioactive Gold, J. J. GUMBLETON. Paper No. 8T. Trend to increasing compression ratio in automotive engines is accompanied by increased demand on ignition system, i.e., voltage required to initiate spark plug discharge; study of theory of pre-ionizing spark gap by means of radioactive material to provide path for current to flow and to reduce voltage required to initiate discharge; tests results are negative and no reduction is realized.

Probing Causes of Piston-Ring Wear by Radiotracer Technique, R. ABOWD, Jr. Paper No. 8U. Problem of adhesive wear, and development of reliable engine schedule for studying effects of fuel and oil variables on wear mechanism; effects of three concentrations of two dispersant-oil additives on adhesive wear mechanism; test technique employed and results obtained in vehicle program undertaken by Ethyl Corp., Detroit, Mich., to observe effects of three fuel blends on wear of topping chrome.

What's New in Brake Linings, N. J. McCUEN. Paper No. 14T. Required characteristics of friction materials used in linings of drum and shoe brakes of duo-servo type; materials are of organic and metallic types; characteristics and method of fabrication of organic dry and wet mix compounds; metallic linings, composed of finely powered iron or copper, graphite and lesser amounts of inorganic fillers and friction modifiers; evaluation of performance characteristics of both types as established by laboratory and road tests; tests on police vehicle.

Monorail Potential, S. H. BINGHAM. Paper No. 15R. Monorail system is proposed as means of transit facility because of its ability to operate above ground level providing safe, fast service at lower installation costs than conventional transportation systems; applicability as transportation means to and from center of city to airports; details of three existing systems: Wuppertal system in Germany, Alweg system in Cologne, Germany, and monorail system in Dallas, Tex.; another type of system under construction is Disneyland-Alweg monorail in Calif.

Dry Ice vs Mechanical Refrigeration in Truck Transport, R. F. ALLYNE. Paper No. 16R. Features of dry ice unit "Econo-Cold," developed by Liquid Carbonic Div. of General Dynamics Corp.; refrigerant is solidified CO_2 at temperature of 110° below 0 F; details of major components of Econo-Cold unit; air circulation is induced by fans; illustrated examples of various applications; performance capabilities; recorder charts demonstrating uniformity of temperatures on short and long movements of frozen and nonfrozen perishables.

Challenge of Efficient Insulation, M. A. KAPLAND. Paper No. 16S. Refrigerated transportation by truck, trailer, etc, and insulation materials used; modes of heat transmission involved; tests to determine value of given insulated unit and basic test data required; present construction and new design concepts; different types of reefer construction; "foam-in-place" insulation using urethane foams; use of modular panels made by same tech-

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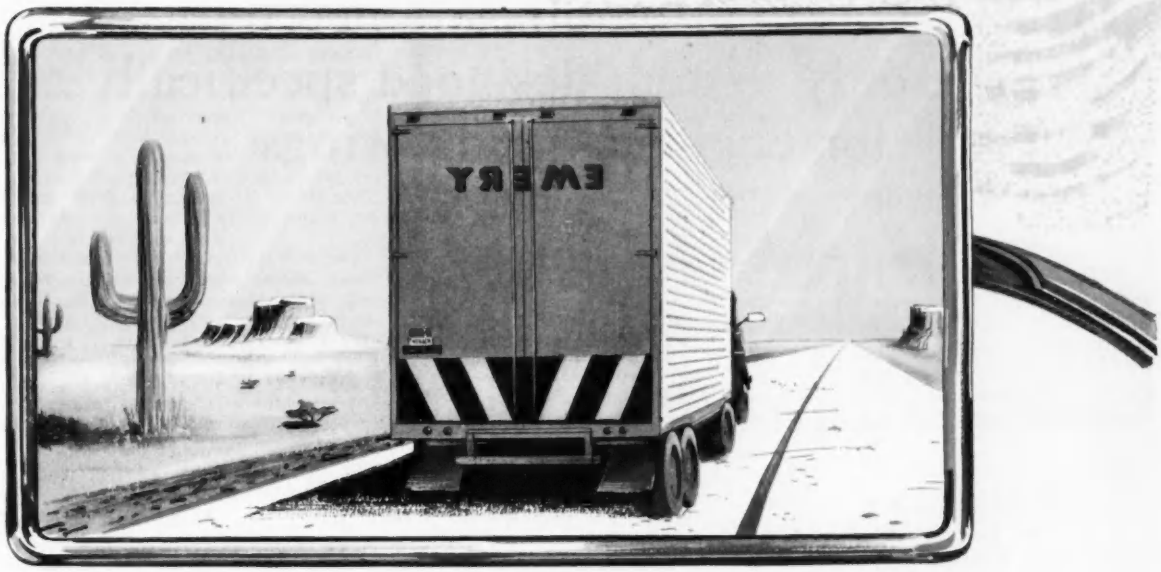
RIGID URETHANE FOAM INSULATION
passes rugged "road test"!



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niques; concept of modular system based on principle of controlled parallel isotherm heat gain.

Power Steering with Natural Feel, R. A. PITTMAN, W. A. Van WICKLIN. Paper No. 19R. Features of Lincoln power steering system manufactured by Ford Motor Co., which is integral assembly of gear reduction unit, power cylinder and control valve within single housing; velocity ratio of gearing is 17 to 1; principle of operation and functions of torsion bar in simulating natural feel; performance characteristics with reference to effort-error relationship, steering effort, torque ratio, and amplification.

New Saginaw Rotary Valve Gear, P. B. ZEIGLER. Paper No. 19S. Design objectives of steering gear developed by General Motors Corp. for 1959 Cadillac, Oldsmobile, Buick, and Pontiac cars, are to achieve instantaneous hydraulic response, to eliminate all possible friction between steering handwheel and hydraulic valve, and to reduce number of seals that could contribute to external leakage, number of components, and overall package size and weight; construction details and flow diagrams; applicability of system to trucks.

New Approach to Optimum Steering Control, A. E. BISHOP. Paper No. 19T. Ways of making control sensitivity of car more uniform are considered; modes of driving and formation of habits; Varamatic concept is defined which amounts to making variable ratio steering gear simulate speed responsive system; evaluation programs of Varamatic steering, conducted by Ford, Chrysler and GM; features of production design of Varamatic semi-integral power steering gear; proposal of integral design; advantages.

Engine Air Flow by Total-Count Method, B. A. FRIES, F. J. DAVIS, D. E. HULL. Paper No. 8S. Useful method to measure air intake in internal combustion engines by means of total-count method, employing Geiger counter and radioactive gas, krypton-85; experimental tests to establish validity of flow method under pulsed flow conditions found in low speed, single-cylinder engine operation; method permits closest approach to natural engine aspiration.

MATERIALS

Reinforced Plastics, E. O. HAUSMANN. Paper No. S147. General

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Continued from page 127

notes on wide range of applications in various industries and predictions made as to their future applications in automotive equipment; production applications of 1-p moldings made of fiberglas reinforced polyester resins such as Corvette and White truck bodies; types of resins, properties and fabrication processes used.

Some Recent Experiments on Friction, Wear and Deformation of Solids, F. P. BOWDEN. Paper No. 17R. Account of some recent experiments carried out at Research Laboratory for Physics and Chemistry of Solids, at Cambridge University, England; Pt I deals with sliding friction and wear of nonmetals, particularly wood, diamond, glass, rubber and metallic carbides. Pt II deals with deformation of solids at very high rates of strain, particularly, with deformation and damage of metals and nonmetals under high speed liquid impact.

Use of Bench Wear Tests in Materials Development, G. H. ROBINSON, R. F. THOMSON, F. J. WEBBERE. Paper No. 17S. Two types of bench wear tests, employed by General Motors Research Laboratories, distinguished primarliy by magnitude of contact stress; constant friction test and high contact load tests; equipment, test procedure and typical applications; test results obtained with steels, cast irons, metallic and nonmetallic coatings on steel; influence of lubricant type and material composition on formation of antiwear films.

MISCELLANEOUS

Incentives to Bring Out Best in Engineers and Scientists, L. B. RICHARDSON. Paper No. S148. Approach taken by General Dynamic Corp., as to some of human relations problems and as to importance of various kinds of incentives as they influence engineers and scientists; role of leadership, team work, communication, recognition; incentive of additional training and education such as graduate study program in engineering developed in conjunction with Southern Methodist University and Convair-Ft. Worth Div.; compensations and opportunities; causes for dissatisfaction.

Physical Measurement — Challenge to Science and Engineering, A. V. ASTIN. Paper No. 21R. Measurement problems, instrumentation and techniques from viewpoint of National Bureau Standards; science and technology discussed in four arbitrary areas; newer fields of scientific investigation such as plasma physics, established areas of research, newer fields of technology such as rocket and missile development, and established fields where precision measurement provide improved performance and reduced costs; examples of problems in these areas.

PRODUCTION

Aluminum Die Cast Cylinder Blocks in Outboard Motors, W. C. CONOVER, R. C. NELSON. Paper No. S146. Experience over 20 yr period at Outboard Marine Corp. in developing cylinder blocks; 16 different types are produced ranging from 1½ to 50 hp; design procedure of 50-hp V-4 cylinder block; die construction method and casting data; process for impregnating; machining and air testing; reasons for use of dry liners; plated and sprayed coatings; use of vacuum die casting made it possible to cast No. 218 alloy successfully.

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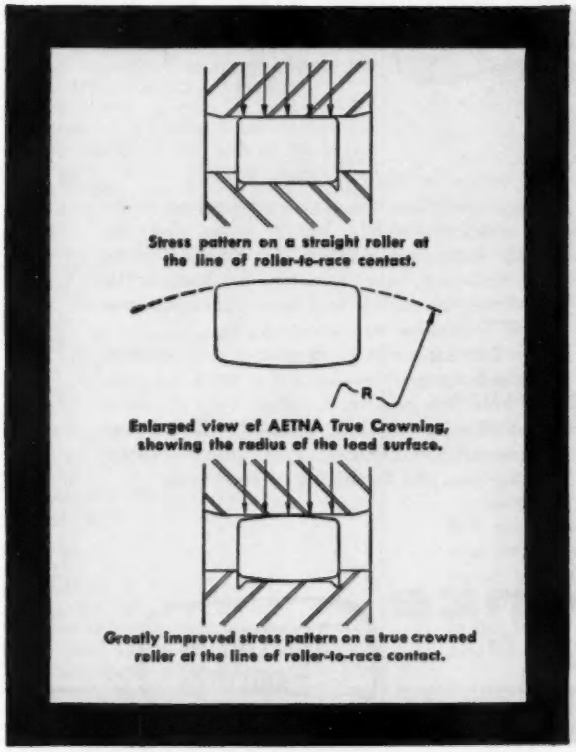

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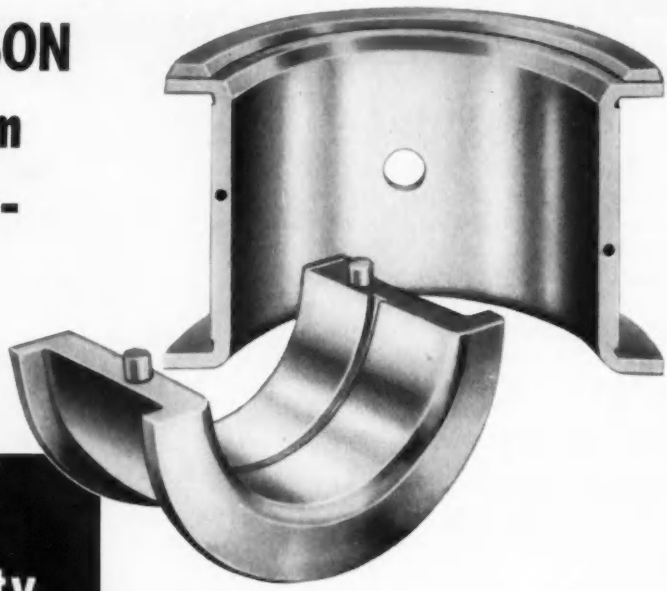

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letters from readers

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It is entitled "Survey of Police Training." It was issued in 1937 as a report of the Regents Examining Committee of the University of Minnesota.

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Thank you for any help you can give us on this.

From:

Ted Powell (A '56), Engineering Aide
Advanced Research and Development Dept.
Hazeltine Research Corp.
Little Neck, L. I., N. Y.

Dear Editor:

"Bucking a Trend"

The recent low-silhouette design trend in the U. S. toward smaller 14-in. and even 13-in. wheels poses some technical questions with regard to tire deflection, temperature, road holding, and life; and to brake drum shrouding, brake fade, and lining life. When it is considered that in going from a 15-in. to a 14-in. wheel, the radius-throw differential and effective car lowering is only ½ in. — and even less in the case of a heavy-car 8.50 or 9.00 tire — the massive industry costs for such a triv-

Continued on page 132

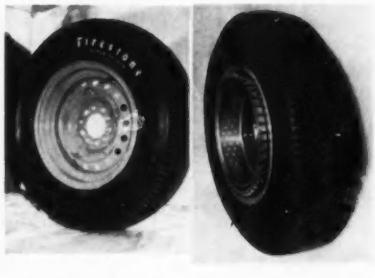
letters from readers

. . . continued

ial lowering of car silhouette could be argued. (Normal suspension coil-spring set can exceed this limit.) Some makes of heavier cars have reportedly run into shortened tire life and brake fade troubles in summer mountain driving with the new 14's.

The writer decided to buck the stream by trying out an experimental 16-in. combo on his modified old 1951 Roadmaster 76C for long and hard runs through mountain country for week-end photo-shooting tours. A set of 16 × 6 Limited Series 90 wheels was exhumed by a Buick dealer and a series of 18 holes of ⅞-in. diameter was punched in the wide hub webs to vent the brake drum heat *a la* MG sports car style. (Buick part No. 1324521.) Note in the photograph (left) the small amount of wheel metal around the bolt circle where the maximum lateral cornering leverage stress point exists. Hence a calculated guess would indicate that the vent-hole weakening of the wheel is a minor concern.

The new-type Buick Al-Fin drums (plus wider flanged wheel hubs) are to be installed up front and the new flanged and finned cast-iron drums at the rear. Note in the photograph (right) the wide ⅞-in. air gap between the drum and wheel rims and the somewhat greater inboard projection of the



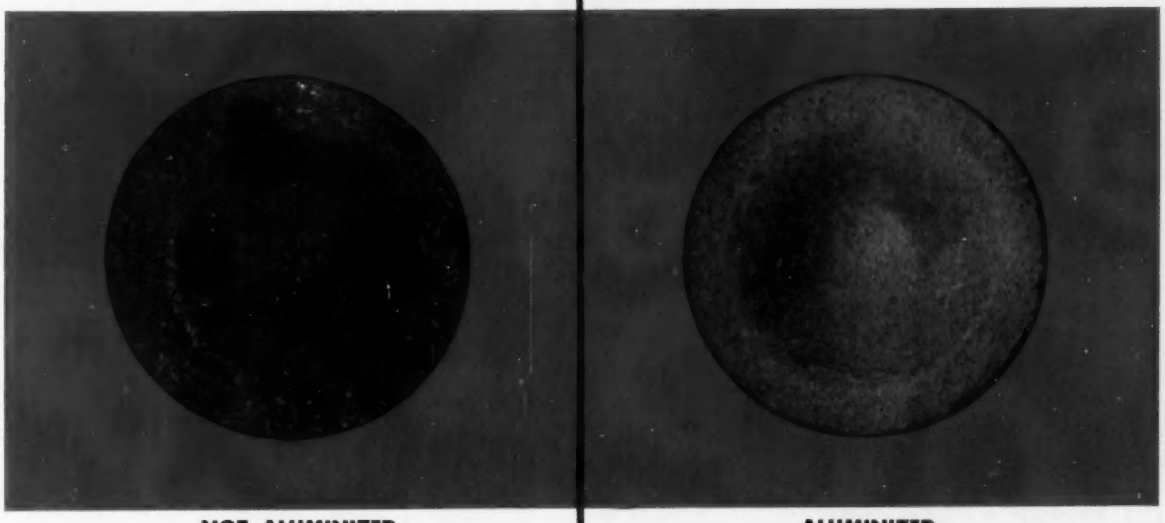
drum flange past the narrow 6-in. wheel rim and into the undercar slipstream.

Since no one makes a 16-in. nylon tire for obvious sales economics reasons, Firestone 7.00 × 16 Supersport 170's were obtained from their Racing Division at the Speedway, Indianapolis. These boots have a business-like, diamond-chain pattern tread which can be heard on a smooth road as a faint whine and rumble if listened for, but really "bite" on the corners, boost

Continued on page 134

The EATON Process of Aluminizing Exhaust Valve Heads PREVENTS PRE-IGNITION

CAUSED BY INCANDESCENT SCALE



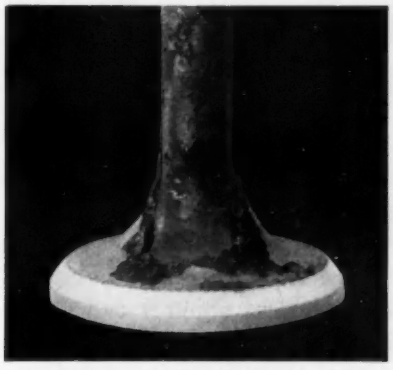
NOT ALUMINIZED
Note Scale which Promotes Pre-ignition

ALUMINIZED
Absence of Harmful Scale Prevents Pre-ignition

Conventional exhaust valve steels, run at high temperatures, tend to corrode and scale, promoting damaging pre-ignition. This condition can be overcome by the use of expensive high-alloy materials. However, there is a simple and less expensive solution to the problem. By applying the Eaton aluminizing process to conventional exhaust valve steel, resistance to corrosion and scaling can be increased tremendously, thereby eliminating a condition which can be a major cause of pre-ignition.

Inlet valves conditioned by the Eaton aluminizing process also are contributing to the increased efficiency, dependability and service life of engines.

Our Valve Division engineers will be glad to discuss the application of Eaton aluminized valves to your engines. Send for illustrated literature.



Aluminizing of Inlet Valve Seat-Face Prevents Oxidation

After aluminizing by the Eaton process, this plain carbon steel valve was placed in an air atmosphere furnace at 2000°F. for 16 hours. Gross oxidation of the base steel resulted. The aluminized seat-face and margin areas were unaffected.

EATON — *VALVE DIVISION*
MANUFACTURING COMPANY
BATTLE CREEK, MICHIGAN

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Truck and Trailer Axles • Truck Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Gears • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

braking traction, and improve road stability — all at some increase in ride harshness. Their very high maximum-speed rating of 140-mph more or less eliminates the tire failure worry in mountain country, assuming no mechanical damage. A 16 also has a much higher load rating than an equivalent-width 15, in this case about 1300 lb for air pressures of 35–45 psi. Apparently, tire load rating is roughly a function of tire torus volume. At a preliminary tire pressure of about 32 psi in the rear units installed at present, car ride is a bit harsher than with stock 8.00 × 15's at 31 psi, but indications are that this can be upped some without getting into dangerous loss of traction on poor road surfaces. Front units have not been installed as yet, so the F/R tire pressure ratios for neutral steer have not been determined as yet for a convertible which packs more weight at the rear. This was a 33/31 F/R tire pressure ratio in the case of the stock 8.00 × 15's, for a 2408/2136 F/R weight-distribution ratio, or 53/47%.

This has been a rather interesting experimental object lesson in the role played by the tire as a spring component in the automotive suspension system. The smaller traction wave, stiffer cord weave, and higher lateral restoring force of the sports car tire make a surprising improvement in harshness. The 16's appear to be far more adept at handling a high up, heavy-weight stock car than the beefy and "shortie" 14's. The combination shown in the pictures might be of some interest to proving ground engineers, who must barrel test cars around test tracks at high speeds for sustained stretches.

From:

R. H. Patchen, Production Engineer
Fabrication Engineering, Dept. 8165
Aerojet-General Corp.
P. O. Box 1947
Sacramento, Calif.

Dear Editor:

Our department is just starting a very comprehensive study for our own Engineering and Research Departments that should be of interest to a great many of your readers.

The project is to establish a Machinability Index for Discalloy 24, Rene 41, Waspalloy, Inconel 700, Udimet 500 and other new super alloys. The evaluation will include dynamometer tests on metal removal, feeds and speeds for optimum finish and tool life, coolants, cutting tools, grinding wheels, etc. The intent is to give design engineers a tool for judgment in weighing the physical characteristics of the alloys against manufacturing costs, with supporting data for production engineers, estimators, and tooling engineers.

We are asking for your help in two ways. First, any published information you know of or have available for sale or otherwise obtainable. Second, the name and address of any companies or individuals working on this problem. We would like to coordinate our efforts with theirs and interchange data.

The report will be constructed so that new material can be added as it becomes available. All contributors will receive full credit and a copy of the report.

Thank you for your consideration.

WHY ROCHESTER-GM CARBURETORS ARE

AMERICA'S NUMBER ONE ORIGINAL EQUIPMENT CARBURETORS!

NEW PERFORMANCE AND ECONOMY FEATURES ASSURE *CUSTOMER SATISFACTION!*

New High In Carburetor Dependability!

Customers sit up and listen—when your sales story includes Rochester-GM Carburetors. For here are new features that deliver the performance and economy you promise.

For example, various models of this year's Rochester-GM Carburetors contain these new features: *built-in hot-idle compensator* to improve idling characteristics, *fuel filter system* to prevent flooding, *fuel bowl venting system* to prevent engine stalling, *vacuum assisted floats* to give better fuel control, *new fast-acting choke* to improve performance and economy during cold drive-away.

In addition, you back your performance and economy story with quality. Rochester-GM Carburetors are engineered exclusively for GM cars. So keep an eye on your customer's satisfaction . . . keep a Rochester-GM Carburetor on his car. *Rochester Products Division of General Motors, Rochester, New York.*

GM

GENERAL MOTORS

America's number one original equipment carburetors

ROCHESTER CARBURETORS

New Members Qualified

These applicants qualified for admission to the Society between February 10, 1959 and March 10, 1959. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

British Columbia Section

F. W. I. Merritt (A).

Buffalo Section

Ernest R. Hugenbruch (M), William H. Jackson (M), Herbert L. Orwig (J).

Central Illinois Section

Duane E. Beals (J), Leonard F. Dickeson (M), Walter R. Egged (J), Alan E. Liffengren (J), Normand Robert Rollins (M), Hwa-Juh Shen (M), David S. Vinton (J).

Chicago Section

Rudolph Bodemuller (M), Ernest C. Carlson (M), Robert F. Shankwitz (M).

Cleveland Section

John B. Crobaugh (M), Frank Davenport (A), John E. Foerst (M), Frank Kadyszewski (J), Paul Laverne Newhouse (J), J. Nicol (M).

Dayton Section

George H. Thomas (A).

Detroit Section

Rodney W. Alexander (M), Arthur A. Ash, Jr. (J), John William Beardmore (J), Melville Guy Boyd, Jr. (M), Donald J. Clark (A), Arnold Irving Cowan (J), Stephen P. Geoffrey (J), Samuel Gleiser (J), John V. Gorton (M), Murray W. Hattin (M), Milton Gene Koenig (M), Svein I. Larsen (M), Frederick E. Lueck (J), Arnold J. Phillip (A), Carlton C. Phillips (J), Robert F. Pressel (A) John Kurt Sauter (J), Anthony J. Vadino (M), Richard F. Walter (A).

Indiana Section

Harry P. Brown (J), Richard S. Button (M), Paul A. Davis (M), Charles M. Foote (A), Stephen L. Gaal (J), Donald Allan Harvey (J), Robert L. Larson (M), Lauriston Calvert Marshall (M), John L. Young (A).

Metropolitan Section

Richard F. Barrett (A), Andre Fonade (M), Ira L. Jackson (M), Harley Dane Kysor (M), Ralph Martin, Jr. (A), Alan Louis Post (A), Barrie V. Potter (M), Allan Jay Rodolitz (J), Walter A. Scheland (M), William Schroeder (A), Martin J. Ungar (J).

Mid-Continent Section

W. A. Hager (A), Horace L. Hale (J), Kenneth H. Yochum (M).

Mid-Michigan Section

Tom B. Miller (M), Theodore F. Ristau (M), Leonard E. Smith (M), Walter E. Welliver (J).

Milwaukee Section

Richard E. Bayerlein (M), James W. Price (M), Milton E. C. Wege (A).

Montreal Section

Bertrand Bouchard (J), John Edwin Hocking (M).

New England Section

Vincent P. Cocivera (J), Charles William Dietrich (J), John W. Kastle, Jr. (M), James C. Livengood (M), Justin M. Margolskee (M).

Northern California Section

Matthew Tenney Campbell (M), Lawrence D. Smith (J).

Nothwest Section

George Bates, Jr. (J), Donald Dale Christiansen (J), Robert Dale Crapo (J), Clare R. Irwin (M), Charles Duane King (A), Kaoru Frank Mizuno (J).

Ontario Section

2nd Lt. Garnet L. Gillespie (A), Fred P. Irwin (M), James George Perrin (M).

Philadelphia Section

Evan B. Ewan (J), John F. Hayt (M), Nelson E. Ockerbloom (J).

Pittsburgh Section

Charles Kerr, Jr. (M), John Mueller Reinhart (M), Edward E. Woodrow (A).

St. Louis Section

Allan Dale Luke (J).

Continued on page 139

protection is stainless steel

Summer or winter the car with plenty of Stainless Steel
is easy to clean and keeps its good looks
under the roughest conditions of driving and weather.

No other metal offers the freedom of design and fabrication,
economy of care and the durable beauty that serves
and sells like Stainless Steel.

McLOUTH STEEL CORPORATION, Detroit 17, Michigan

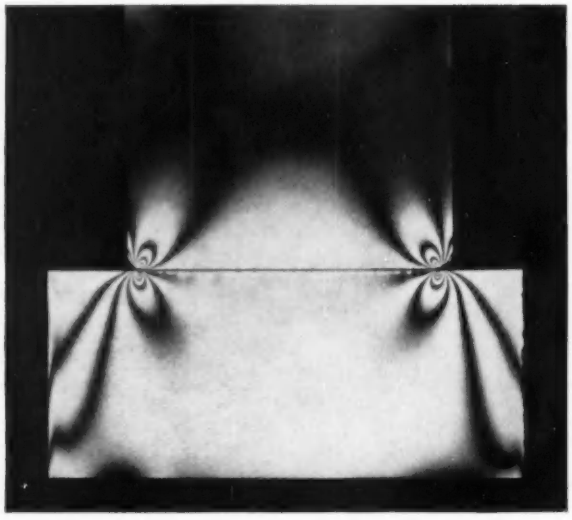
specify

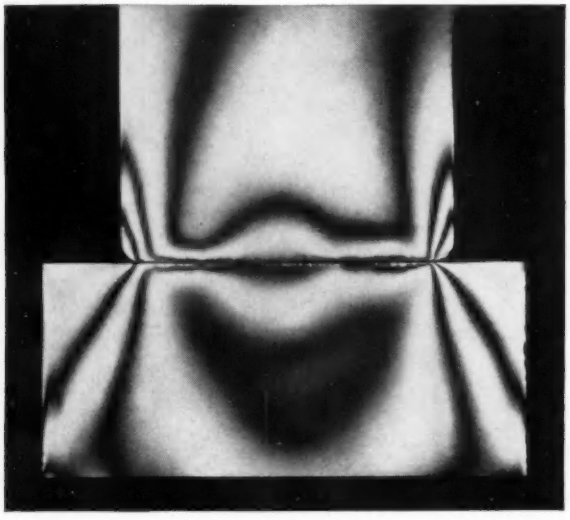
McLOUTH STAINLESS STEEL

HIGH QUALITY SHEET AND STRIP

for automobiles

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

New Members Qualified

Continued

San Diego Section

Wesley Eugene Kauder (J), Clifford E. Parver (J), Gordon J. Twa (J).

Southern California Section

Robert A. Bailey (M), Dale G. Carey (M), Leonard F. Griffing (A), Richard E. Keeffe (J), Nathan Lockman (M), James D. Moore (J), Jerry L. Moredock (J), Emilio Peter Muras (M), Roy D. Nickerson, Jr. (A), James Barr Pentecost (A), Peter Scott-Brown (M), Michael Voytish, Jr. (M).

Southern New England Section

Richard J. Dalphin (J), Martin Macklin (J), Gordon B. Mannweiler (M), Bernard L. Schulman (M).

Spokane-Intermountain Section

Walter Z. Davis (M).

Texas Section

Robert K. Kolster (A).

Twin City Section

M. B. Green (M).

Williamsport Section

Julius J. DeCarolis (M).

Outside Section Territory

J. A. Coll (M), Clyde R. Gilbert (M), Thomas E. Harmon (M), Earl G. Heimbach (M), J. F. Whitlow (A).

Foreign

Prof. Pushkaraj Lilaram Ballaney (M), India; Gualterio A. Biberschick (M), Brazil; Jacobus Jozef Kok (J), Liberia; Charles Nicholas Moir (A), So. Africa; Juan Carlos Quaranta (M), Argentina; Lawrence Smurthwaite (A), England; Tadamasa Yoshiki (M), Japan.

Applications Received

The applications for membership received between February 10, 1959 and March 10, 1959 are listed below.

Alberta Group

Dennie W. Anderson, David L. Palmer, D. H. Pugsley

Buffalo Section

Clarence J. Eckert, Ralph C. Mangold, Charles N. Moore, Harrison V. Nowalis, R. Dewey Rinehart, Benjamin N. Snyder

British Columbia Section

William J. K. Gibson

Central Illinois Section

John R. Aymer, Norman T. Mattson, Ronald J. O'Mara, Rex Piha, Ronald G. Rumpf, Chester P. Swan, David S. Ullman

Chicago Section

James S. Bray, John W. Little, John E. Mazanet, James McLaughlin, Van K. Mefford, Richard A. Shoits, William L. Sieker, Harry R. Smith, Jr., Richard Warrington

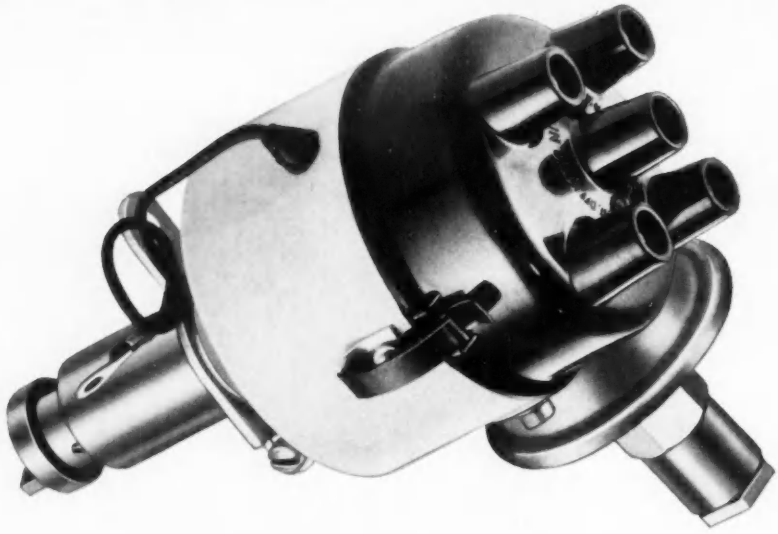
Cleveland Section

James M. Hooper, Wilfrid S. Johnston, William D. Mathers, Harry Ralph Niefert, Alfred W. Tucker, Richard Allen Wise

Continued on page 141

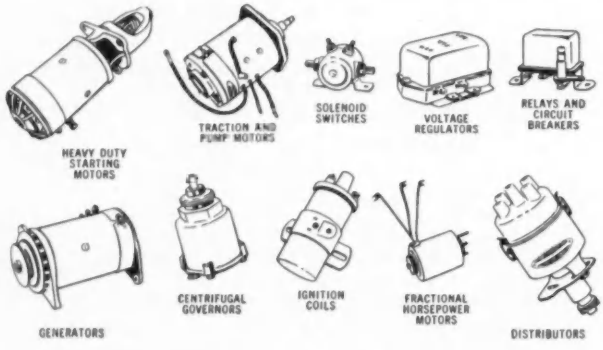
NOW...FROM AUTO-LITE

SIX NEW IMPROVEMENTS IN DISTRIBUTOR DESIGN



NEW COST REDUCTION SERVICE FOR MANUFACTURER CUSTOMERS

Programs that include design, engineering, methods, automation and manufacturing are all contributing to the important new cost reduction service of the Electrical Products Group of Auto-Lite. Included are greatly expanded research and engineering activity, facilities for field training and servicing and District Managers prepared to assist customers and prospects in their drive for lower costs.



Now Auto-Lite offers a completely new distributor design. Ignition engineered for 4-, 6- and 8-cylinder automotive and industrial applications, this new, low friction governor distributor is extremely rugged and dependable. Here, for example, are just six of the many advantages of this new distributor:

1. Weight savings of approximately 40% over most other designs
2. Non-corrodible distributor bowl that is salt spray resistant and unaffected by marine and tropical environment
3. Low hysteresis governor advance design for high accuracy of calibration of speed versus spark advance
4. Glass-filled high temperature resin base molded around a powdered iron bearing pedestal
5. Long life lubricated sintered iron cam element and weight element
6. Lubricant capacity six to eight times that of conventional oilers means long life lubrication for the distributor bearings

This unit is available in either vacuum or non-vacuum types and with a variety of precisely engineered seals to prevent penetration of dust, water, or oil.

AUTO-LITE®

ELECTRICAL PRODUCTS GROUP

THE ELECTRIC AUTO-LITE COMPANY, TOLEDO 1, OHIO

Applications Received

Continued

Colorado Group

Balthasar T. Bollig, George Hollis

Detroit Section

Arthur A. Bibeau, F. Dale Buerstetta, Frederick A. Burne, Robert M. Doll, William C. Erdman, Glenn R. Green, Stanislas H. Hage, Z. Louis Horvath, Charles A. Jones, Kenneth Martin Jordan, Ernest P. Kiraly, Robert C. Lenat, Donald G. Martus, Roy E. McCarter, Matthew C. Patterson, Clayton F. Paquette, Ronald R. Perkey, Lloyd E. Peters, Alfredo R. Ragazzi, Frederick W. Sabur, Daniel J. Selmeyer, James D. Shircliff, John W. Skelley, Virgil Reed Stump, Fred W. Uhl, William G. Welsh, Fred West, Richard Whipp, John L. Metevier.

Hawaii Section

Robert A. Silverman, Edward T. Wilson

Indiana Section

A. R. Clark, Richard H. Cook, Lester M. Harlan, Joseph A. Keirans, Jimmie D. Pinney, Wilford E. Smith, Donald E. Williams

Kansas City Section

Theodore Dechman, Jr., Ivan G. Divelbiss, Arnold L. Spurlock

Metropolitan Section

Donald L. Botway, Richard O. Braendle, Claudio J. Carnali, Stephen C. DaCosta, Nickolas P. Demas, William G. Dukek, Jr., Russel T. Fick, George A. Finn, Anthony V. Frasca, Adam Metzner, Edmund Sennert, K. R. Seshadri, Warren C. Wilson.

Mid-Continent Section

Elvin O. Campbell

Mid-Michigan Section

Donald L. Bell, Robert E. Dolan, Robert C. Kerchner, Ernest M. Plant II, John R. Trcka, R. B. Wells, Gunter Wickel

Milwaukee Section

I. F. Herbes, Robert A. Lofy, Walter J. Mayer, Lloyd F. Sippel

Montreal Section

M. F. Fitzgerald, Lawrence G. Mallett, Trevor Williamson

New England Section

Norman J. Cyphers, Jerome E. Ruzicka

Northern California Section

E. P. DeBerry, Roger Horner, Thomas E. Leonard

Northwest Section

John D. Morell

Ontario Section

William R. Chapman, Andrew C. Lyon, James J. Taylor

Oregon Section

M. Hamer Phillips, Thomas A. Rice

Philadelphia Section

Albert C. Condo, Jr., Dominick Verno

Pittsburgh Section

Nick Nicklas

St. Louis Section

Leonard B. Graiff

San Diego Section

Carl G. Ard, Paul R. Becker, Ralph W. Bledsoe, Paul J. Deboo, Roland J. Fornataro, Edward F. Gruenemay, Jr., Leroy A. Hughes, Benjamin L. Irvine, Richard M. Kirby, Richard U. Perry, Melvin Wilson

Southern California Section

William J. Baldwin, Dennis E. Bowman, David A. Bryson, David R. Cook, Anthony R. Lamb, Richard R. Laskey, Robert F. Preston, Finley H. Rhodes, Charles M. Savage, Jr., A. Lawrence Stone, Joseph R. Timlin, John S. Winter

Southern New England Section

Einar M. Ramberg

Syracuse Section

Edward W. Fisher

Texas Section

Lowell B. Baird, R. C. deWaal

Twin City Section

Lloyd A. Kerber, William B. Kletzin

Virginia Section

Woodrow A. Rodriquez

Washington Section

Jack Norton

Western Michigan Section

Charles Derler

Outside of Section Territory

George S. Allin, Jr., Charles E. Barnum, Lloyd Ethington, Wilhelm E. A. Schmidt

Foreign

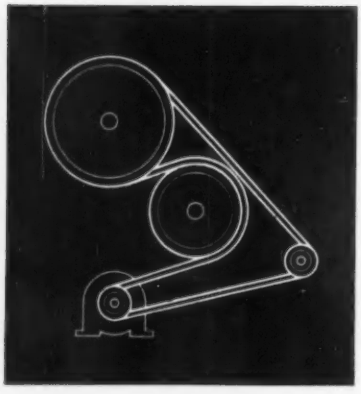
Norman C. Gardener, England; James L. McVay, Argentina; Albert C. Simille, France; Eugene D. Williams, New Zealand

V-Belt Designer's Notebook

A special V-Belt Engineering Service to help you cope with 7 Drive Problems created by space-saving modern design

A checklist of V-belt drive designs which require specialized engineering. With a description of the compensating characteristics which can be built into special Dayton V-Belts. Sources: Case histories from the files of the Dayton Special V-Belt Engineering Service and "The Dayton Handbook of V-Belt Drive Design and Selection."

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton V-Belt Drive.

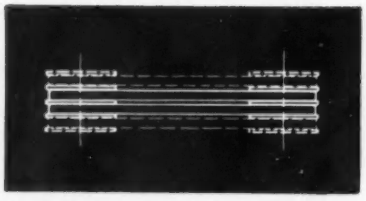


Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take-up area. Yet the design is efficient because Dayton V-Belt engineers developed a belt especially adapted to these three punishing conditions.

You'll find similar examples in machine tools, agricultural machinery and wherever drive space is limited. You've seen them yourself—the designs which dictate sheave misalignment, back-side idlers, underbelting; plus others which use V-Belts as a clutch and which impose excessive shock loads on the belt.

HERE ARE THE MAJOR CONDITIONS WHICH AFFECT V-BELT PERFORMANCE

Underbelting

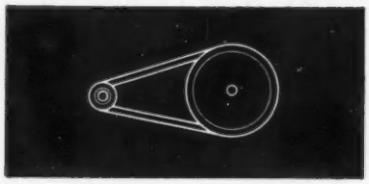


Underbelting is found where space is limited or as a result of very low belt speeds. It will cause belts to slip, run hot and wear out very quickly. A temporary cure, commonly employed, is to over-tension the belt – thus throwing excessive loads on the bearings.

The design requires a high capacity belt with extra-strength cords found in Dayton's Super-Thorobred series or, in difficult cases, belts with both a high coefficient of friction and extra strength like the raw-edge Dayton Cog-Belt.*

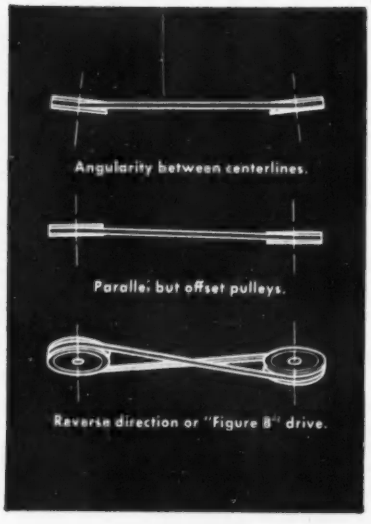
Sub-diameter sheaves

Belts driven by sub-diameter sheaves are inclined to succumb to accelerated flex failure. Tensioning problems are a usual result.



Sub-diameter sheaves require extremely flexible belts for satisfactory service. The required flexibility may be obtained by using thin V-Belts—where drive capacity is not high. When considerable capacity is required, Dayton Cog-Belts will give the most satisfactory performance. Their exclusive design permits exceptional flexibility. Die-cut raw edges provide high coefficient of friction, transmit maximum power from sub-diameter sheave arcs.

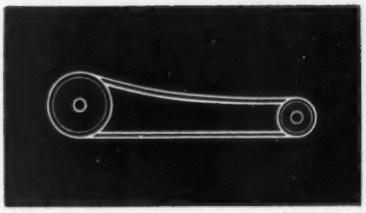
Misalignment



Misalignment causes uneven tension across the face of the belt—producing abnormal belt and pulley wear and uneven bearing loads.

A suitable approach is to use highly extensible cords of the latest synthetic fibers in the strength band of the V-belt. Dayton's Development Engineer can prescribe the material best suited to your needs.

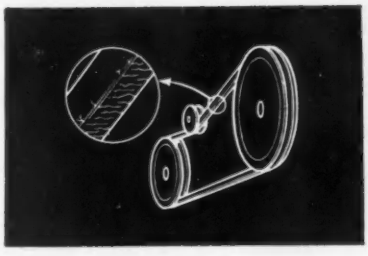
Fixed centers



Proper tension cannot be maintained with fixed centers or where center distance adjustment is inadequate. Without proper tension, belts slip and need frequent replacement.

Dayton V-Belts with low-stretch neutral-axis cords are best suited for applications with little or no provision for center distance adjustment. Still higher performance is gained if the belts have maximum cross-sectional stability which helps keep the belt from seating in the sheave groove.

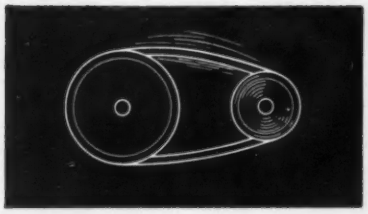
Back-side idlers



Cracks will appear on the under side of the belt, since back-side idlers force the belt to flex in a direction contrary to its construction. Use of spring-loaded back-side idlers may result in belt-snapping.

Where back-side idlers are used to provide tension take-up, they must never be smaller than the smallest pulley in the drive. Dayton V-Belts used in this case employ tension or stretchy type materials in the compression section and have a relocated neutral axis.

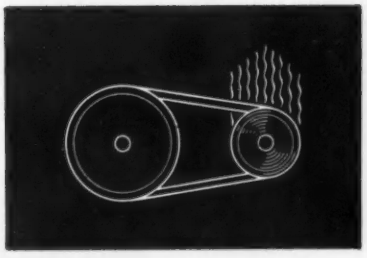
Excessive shock



Excessive shock can cause the belt to snap as well as promote bearing troubles and sheave misalignment.

Belts subject to excessive shock or heavy pulsation require strength band constructions which offer changeable ratios between stress and strain without taking a permanent stretch. Belts with soft cross sections — that will ride up and down in the groove — work well under shock as do wide angle belts. Any of these belts are available from Dayton.

Using as a clutch



V-Belts are ordinarily designed for constant loads and will burn when used as a clutch.

But, belts especially designed for use as a clutch will readily slip when a load is suddenly applied or released. Dayton cover stocks used here have a low coefficient of friction and high resistance to wear.

DAYTON'S SPECIAL V-BELT ENGINEERING SERVICE

Make use of Dayton's Special V-Belt Engineering Service when you encounter any of these designs. Your Dayton V-Belt design engineer is an expert who has devoted himself exclusively to V-Belt Drives. Your design may permit a minor modification which would adapt it to the use of low-cost standard V-Belts. Other standard Dayton V-Belts available for special applications are the Double-Angle V-Belt, the Double Cog-Belt, the Variable Speed Cog-Belt and the Back-Side Idler V-Belt.

With one of the finest research and development laboratories in the industry, Dayton research engineers constantly advance V-Belt knowledge. They develop basic theory, prove the characteristics of the newest compositions and materials available to the rubber industry and test the performance of theoretical constructions. All of this acquired information is at your call when you need a special V-Belt.

Now, while your design is on the drawing board, is the time to call your Dayton V-Belt design engineer. He'll help you select the V-Belt which is tailored to your specific drive. The result — a compact, versatile design which meets all your minimum design requirements and one that will give its users years of trouble-free service.

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.

*T. M.

Dayton Rubber

THE DAYTON RUBBER CO., INDUSTRIAL DIV., DAYTON 1, OHIO
WORLD'S LARGEST MANUFACTURER OF V-BELTS

If you haven't received your copy of Dayton's authoritative Handbook of V-Belt Drive Design and Selection, write for it now. Just give us your name, title, and the address of your firm.

New 6-cyl. UC-263 develops 95 max. hp @ 2400 rpm.

New 6-cyl. UC-221: 75 max. hp @ 2400 rpm.

Three NEW heavy-duty International engines with long-life features

Newest heavy duty carbureted engines in the International line are two compact 6-cylinder models, the UC-263 and UC-221, rated at 95 and 75 max. hp @ 2400 rpm, and the rugged 4-cylinder 42 hp UC-135.

While these three new engines vary in power ratings and numbers of cylinders, they have much in common: fuel saving combustion on gasoline, LPG, or natural gas; efficient valve-in-head design; long-life pressure lubrication; replaceable sleeves; thorough sealing against life-shortening dust; updraft carburetion, factory-engineered power unit components and attachments for individual requirements.

Many of the rugged features associated with diesels are found in both the new UC-263 and UC-221. These engines are physically interchangeable with their direct-start diesel counter-parts—the 95 hp UD-282 and the 75 hp UD-236.

Other features of the UC-263 and UC-221 models: 7.2:1 compression ratio and 18 mm plugs for best fuel economy on regular gasolines; fully machined combustion chambers for uniform power output; exhaust valve rotators for long valve life; 12-volt starting and ignition system for fast starts in cold weather; low friction stepped-dome pistons; and deep I-block crankcase.

For more details on these or any of the other 21 carbureted and diesel engines in the International power line, write or call International Harvester Co. Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

New 4-cyl. UC-135: 42 max. hp @ 2000 rpm.

International® *Construction Equipment*

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

XXX

This is the thirtieth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Evaluating the Machinability of Alloy and Carbon Steels

To produce a useful part, most steel has to be shaped by one or more of the metal forming methods. One of these is metal cutting or machining, which changes the shape, size, or finish of a workpiece.

Alloy or carbon steels are often received from the mill in the raw form of bars, forgings, or castings. The steel is placed in a suitable machine, such as a lathe, multiple-spindle automatic bar machine, drill press, milling machine, or one of a number of other types. Metal is then removed from the steel stock until it has acquired the desired shape. This is accomplished by causing motion to take place in the sharp-edged cutting tool, or the piece of steel, while they are held in contact with each other. Cutting tools, such as drills, tool bits, milling cutters, and the like, are made from highly-alloyed steel (tool steel), cast alloys, sintered carbide, or even ceramic material.

During machining, the metal is removed in the form of chips which may be of any length, from the short, well-broken type, to the long, stringy and continuous variety—depending upon the nature of the steel, the shape or geometry of the cutting tool, the speed and feed at which the cutting is done, and the coolant or cutting fluid applied.

"Machinability" of steel refers primarily to the ease with which it can be reduced to its final shape. It is measured by the speed and feed at which it can be cut, the quality of the surface finish produced, the length of time the tools will last, and the kind of chip formed in cutting. In a "free-machining" grade of steel, for example, high speeds and feeds can be used, tools will stand up well, surface finish will be good, and chips well broken.

Machinability is evaluated in the shop by the number of pieces having a satisfactory finish, within the required dimensional tolerances, that can be produced in a shift, or a day, with adequate tool life.

It can be appreciated that the study of the cutting of metals involves a large number of variables. These may be grouped in the following way:

1. Steel Analysis (Process, composition, microstructure, and mechanical properties)
2. Machine Tool (Condition, tool accessories, range of cutting speeds and feeds with ample power, etc.)
3. Type of Machining Process (Turning, milling, forming, broaching, etc.)
4. Cutting Condition (Speeds, feeds, and depth of cut)
5. Cutting Tool (Composition, treatment, hardness, size, shape, grinding and surface finish)
6. Cutting Fluid (Characteristics, application, and volume)

From this number of complex factors, laboratory tests and investigations have developed experimental data by using single variables, such as steel analysis, tool analysis, tool shapes, and cutting fluids. This information has proved to be a useful guide when combined with industrial experience; for no test method by itself has yet been developed that will include all the characteristics of a specific single or multiple-machining operation.

Bethlehem metallurgical engineers have had long and varied experience and knowledge on the machinability of alloy and carbon steels. They will gladly give you any help you may require in connection with machining problems.

In addition to manufacturing all AISI standard alloy steels, Bethlehem produces other than standard analysis steels, and the full range of carbon grades. Call your nearest Bethlehem sales office for information.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in this series are now available in a handy 44-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

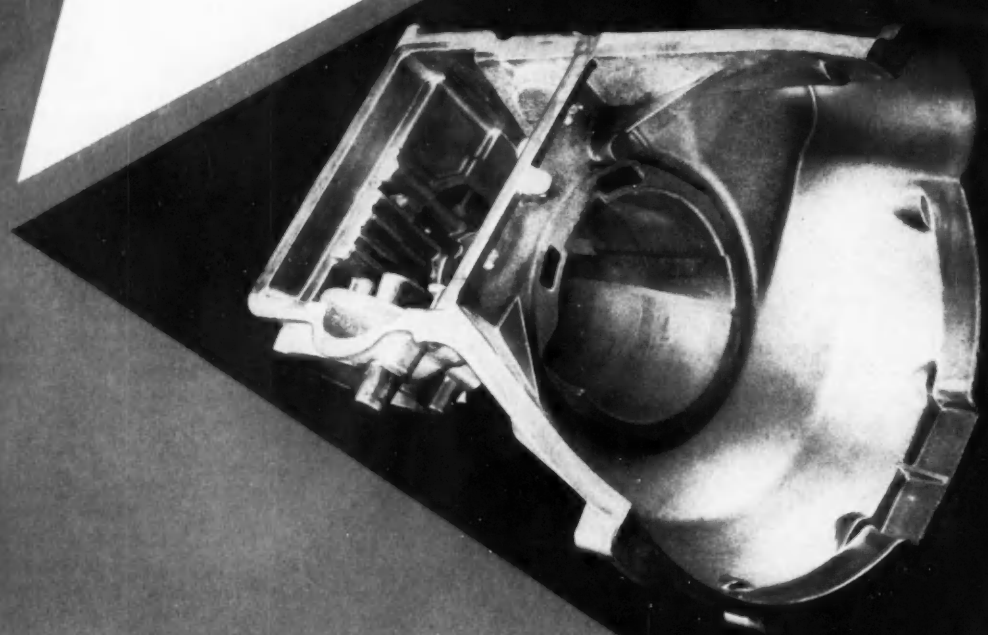
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

FORD SLASHES 61 POUNDS OF DEADWEIGHT

with new one-piece aluminum transmission case



When the Ford Motor Company decided to shift to aluminum for their transmission converter housing and gearbox, they drew on the unsurpassed experience of Alcoa's Development Laboratory engineers. Starting at the design and testing stages, they received valuable design recommendations that enabled them to mass produce—at the lowest possible cost—a high-strength aluminum transmission casting that weighs just 24 pounds.

Lightweight, Permanent Mold Casting. At the outset, the permanent mold casting process was chosen to withstand the extreme stresses in this application and yet provide a very light casting. Because this process permits thinner walls, a weight saving greater than the normal 3-to-1 ratio of cast iron to aluminum was effected. A cast iron casting of the same design would weigh 85 pounds or 61 pounds more than the new aluminum casting.

Produced Faster at Less Cost. The one-piece casting replaces four parts. It eliminates the cost and time of fabricating and assembling separate iron flywheel housing, iron gearbox, and front and rear aluminum die-cast servo bodies.

In addition, Alcoa design suggestions permit the use of permanent mold alloy 333F, an alloy that provides even greater savings since it needs no heat treating.

Aluminum Die-Cast Extension, Stator, Valve Body. The total weight of these die-cast aluminum transmission parts is about 10 pounds. Because aluminum die castings can be made to accurate tolerances, machining costs are lower. Their practicality and economy have been proven in over seven years of actual use.

Let Alcoa Help You. Alcoa's laboratory facilities, manned by skilled and experienced engineers, can help you get the most out of aluminum at the lowest possible cost. Team up with Alcoa Development Division engineers at the initial design stage; they'll help you evaluate casting methods for particular applications and advise you on alloy control, dimensional stability and interpretation of test data. Write Aluminum Company of America, Development Division, 1785-D Alcoa Bldg., Pittsburgh 19, Pa.

ALCOA ALUMINUM gives every car more GLEAM AND GO

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," every Tuesday, ABC-TV

The AiResearch Centralized Air Data Computing System will sense, measure and automatically correct for air parameters affecting flight of the North American-Air Force F-108 Interceptor and will supply simplified air data to the pilot. Eliminating duplication of components, the system will cut down space and weight requirements over decentralized systems by many times.

The centralized combination of transducers, computers and indicators represents an integrated system concept combining electrical, electronic, pneumatic, hydraulic, electro-mechanical and mechanical servo capabilities. Technical experience in each of these fields enables AiResearch to achieve optimized systems covering a wide range of functions while meeting the most rigid specifications. Systems management is an integral part of each Central Air Data program enabling AiResearch to assume the overall responsibility for systems or subsystems.

The first fully optimized central air data system is already operational aboard the Navy's supersonic F4H-1, the first aircraft to fly with such a system. Similar equipment is on the Navy's first weapon system, the A3J "Vigilante." This broad AiResearch systems capability is now being applied in the fields of military aircraft, commercial jet transports, missiles and submarines.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

LIPE

Adapted to changing vehicle horsepowers, loads and use requirements

That's why you get more ton-miles and more engagements per mile out of a Lipe Heavy-Duty Clutch

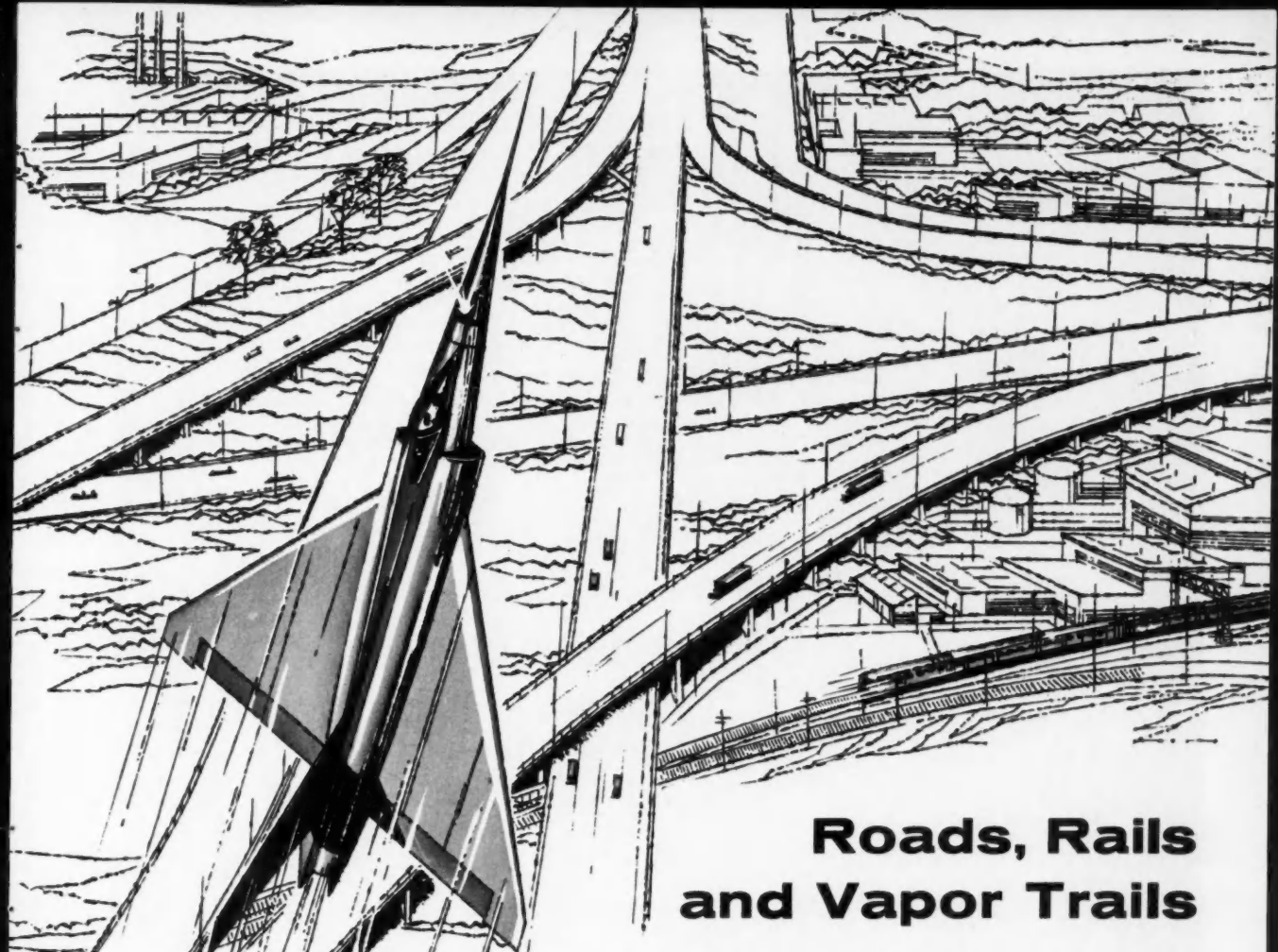
At Lipe-Rollway our automotive division makes heavy-duty clutches . . . and nothing but heavy-duty clutches. We've been devoting our research, development, technology, equipment and skill to that job for years.

Today, the list of Lipe clutch users reads like a "Who's Who" of the heavy-duty vehicle industry. Tens of thousands of Lipe clutches are in daily service . . . thousands more are added each year. That is because our constant aim has been to build a more serviceable clutch, continuously adapted to changing vehicle horsepowers, loads and use requirements.

Advanced equipment, flexible deliveries, shorter lead times, a planned program of design development, all make Lipe the clutch best suited to serve you. *Let our engineers work with your men to give you a clutch engineered to your job. Write for information.*

Lipe-ROLLWAY CORPORATION SYRACUSE 1, N.Y.

MANUFACTURERS OF AUTOMOTIVE CLUTCHES AND MACHINE TOOLS



Roads, Rails and Vapor Trails

Whether it hugs the earth or rides the stratosphere's jet streams, **modern** transportation has one **un**common denominator—stainless steel.

America's first **supersonic** bomber — the world's **lightest** full-size, railroad passenger car—the trucking industry's **highest capacity** lightweight trailer—all owe their existence to stainless steel's extraordinary strength-weight ratio and almost indestructible good looks.

Every American auto on the road today uses stainless steel functionally and decoratively to protect painted and treated surfaces, because only stainless steel requires no protective treatment to preserve factory freshness and assure lasting customer satisfaction. **And** its unusual workability means that finished product costs are usually lower than for any other bright metal.

Whether your primary interest is function or form, J&L provides **consistent** quality for uniform production.

J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, **and production economies begin.**

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

J&L
STAINLESS
SHEET • STRIP • BAR • WIRE

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

ENGINEERS–SCIENTISTS

Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

$$\sqrt{1-\frac{v^2}{c^2}}$$

This human application of the relativistic theory of space-time relationships is predicated on the conviction that the creative content of technological thinking can be immeasurably expanded and enriched—given a propitious environment.

That the environment at Republic *is* propitious, is evident from the results.

Engineers and scientists like it. They thrive on it. Technical ideas of a "revolutionary" character—rather than "evolutionary"—are appearing at a rate that exceeds the norm of even 5 years ago.

In every professional area—research, development, experimental engineering—*the goal is the same:*

TELESCOPING TIME

in terms of technological progress

▶ *in exotic propulsion systems for space operation—plasma propulsion...advanced nuclear power applications...*

▶ *in integrated electronic systems for flight vehicles to operate at every altitude*

▶ *in supersonic and hypersonic weapons systems, both manned and unmanned*

For an invigorating environment, where new ideas flourish, look at the range of opportunities at Republic

ELECTRONICS
Inertial Guidance & Navigation • Digital Computer Development • Systems Engineering • Information Theory • Telemetry-SSB Technique • Doppler Radar • Countermeasures • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment

THERMO, AERODYNAMICS
Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Airplane/Missile Performance • Air Load and Aeroelasticity • Stability and Controls • Flutter & Vibration • Vehicle Dynamics & System Designs • High Altitude Atmosphere Physics • Re-entry Heat Transfer • Hydromagnetics • Ground Support Equipment

PLASMA PROPULSION
Plasma Physics • Gaseous Electronics • Hypersonics and Shock Phenomena • Hydromagnetics • Physical Chemistry • Combustion and Detonation • Instrumentation • High Power Pulse Electronics

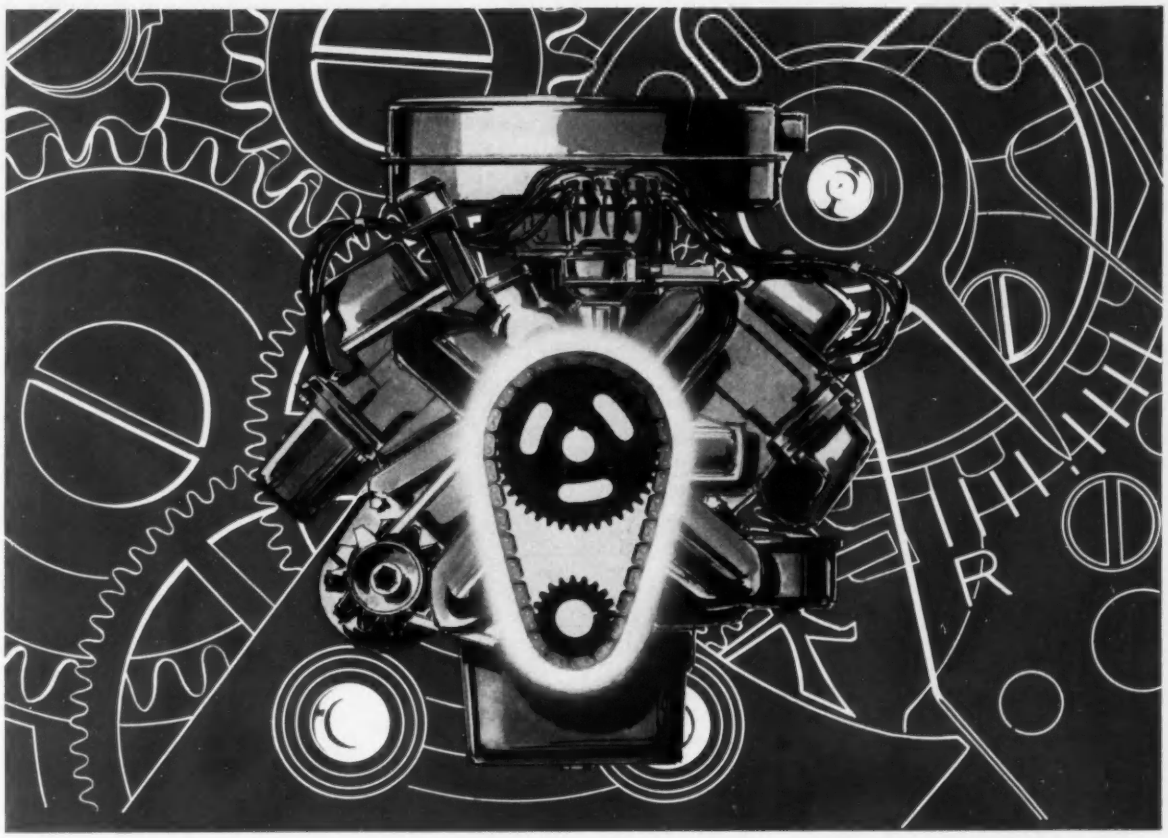
NUCLEAR PROPULSION & RADIATION PHENOMENA
Nuclear Weapons Effects • Radiation Environment in Space • Nuclear Power & Propulsion Applications • Nuclear Radiation Laboratories

A new $14,000,000 Research Center—to be completed this year—is part of Republic's far-ranging R&D programs aimed at major state-of-the-art breakthroughs in every flight regime and environment.

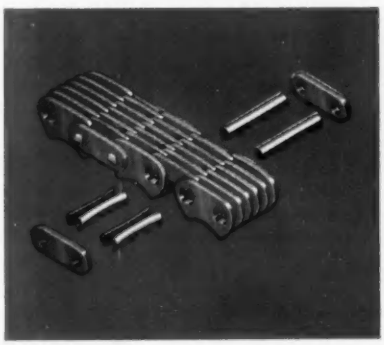
Send resume in complete confidence to:
Mr. George R. Hickman, Engineering Employment Mgr., Dept. 7D

REPUBLIC AVIATION

Farmingdale, Long Island, New York



Precise as a watch... and nearly as quiet, Morse Silent Chain times most car engines!



Spring-bushing joint construction of Morse Timing Chain serves as a friction damping device to minimize noise and wear. This new bushing also cuts joint vibration and reduces the tendency to "whip"; provides for take-up of slack. Ask for Catalog C60-51.

Specially designed for passenger cars by Morse ... only company that makes ALL 4 basic drives

Designed for precision timing of today's high-horsepower engines . . . engineered to passenger-car standards of quietness: this is Morse Silent Chain—original equipment on over 80,000,000 engines.

Actually, Morse Silent Chain is built like a fine watch. And exacting quality controls maintain these rigid standards; insure motorists of trouble-free timing for *extra* thousands of miles. Morse has been building this dependability into timing chain for over 55 years.

So for original equipment or replacement timing chains, check first with Morse. Want more information or practical engineering help? Call, write or wire today: Morse Chain Company, Detroit, Michigan; Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd.; Simcoe, Ontario.

MORSE MORSE B-W BORG-WARNER * A BORG-WARNER INDUSTRY

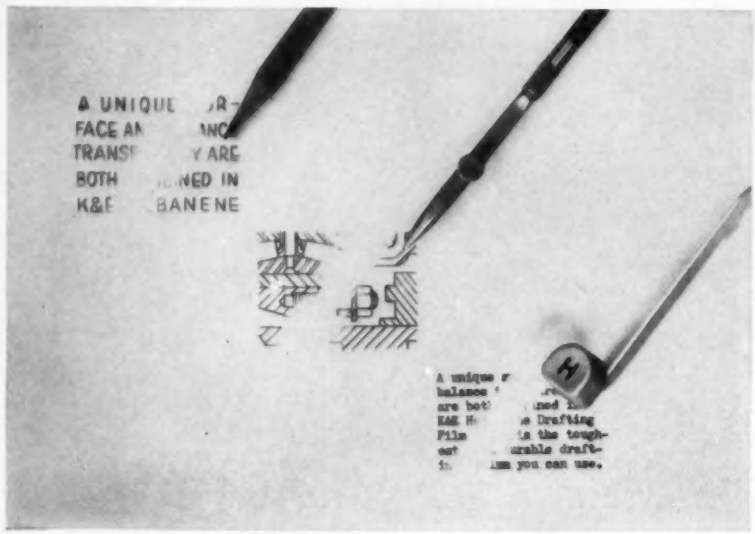
*Trademark

ONLY MORSE OFFERS ALL 4: Roller Chain, Silent Chain, Hy-Vo® Drives and "Timing"® Belts

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.



Now you see it . . . now you don't. Pencil, ink and typing all register sharply, erase completely on the K&E "engineered surface."

The K&E "Engineered Surface"

All K&E paper, cloth and film has one extremely individual characteristic. It's what K&E calls its "engineered surface"... a unique surface designed and applied by K&E, right in its own plant, to every roll and sheet of prepared tracing paper, cloth and film. It means controlled drafting qualities far beyond anything the base material alone can normally provide, with a surface tooth that's exactly right and uniform. Whatever's penciled, inked or typed onto it goes on crisply and sharply . . . shows up clearly and stays that way. Furthermore, the "engineered surface" lets you erase if you want to, easily and quickly and without any of those leftover ghost lines that drive you crazy when they show up in reproductions. And remember, only with K&E do you get all the advantages of an "engineered surface," no matter which paper, cloth or film you're interested in.

About HERCULENE (TM) The Newest of Films

Frankly, we think K&E Herculene Drafting Film is a real discovery. It has all the properties of the K&E "engineered surface" . . . exceptional "take," adhesion and erasability . . . plus the toughness and durability of its Mylar® base. What's the latter? It's a polyester film, developed by DuPont, that's uncommonly strong and virtually indestructible . . . waterproof and almost immune to the effects of age, heat, ultraviolet exposure and handling. With our K&E "engineered surface" added, it becomes K&E Herculene Drafting Film . . . the toughest, most durable drafting medium yet to reach the drafting room. And the surface will last indefinitely, without flaking off or chipping off.

Some Points About Paper...

K&E Albanene® Tracing Paper is the largest selling tracing paper in the world today. Why? Because Albanene is the *only* prepared tracing paper which has an "engineered surface." All other brands depend for their pencil tooth solely on the natural surface texture of the paper itself, which varies from fine to coarse . . . often on the same sheet.

Albanene invariably gives you sharp, clear pencil lines, superb reproductions. It has a solid transparentizer that is chemically stable and can't leak out, ever. This permanent transparentizing means that you'll never get white, opaque spots, even from contact with drafting tape. Try the drafting tape test yourself.

...and its package

And now, all Albanene paper in rolls is packaged in the new square carton for better protection and easier storage. Your rolls stay neat and clean while in use, and the cartons will do double duty in helping you to store finished tracings. In fact, some companies are rearranging their filing systems by using Albanene cartons, which hold large numbers of rolled-up drawings and stack simply and neatly.

Some Facts About Cloth

When you want cloth, think first of K&E Phoenix® Tracing Cloth. Besides the K&E "engineered surface" with the superb "take", adhesion and erasability for pencil, ink or typing, K&E Phoenix has all the advantages of a water-resistant, chemically-inert coating that won't soften even under high heat and won't discolor, become brittle or flake off the base. You can even clean both sides with a damp cloth, without worrying about moisture stains.

And Some Tips On Erasing

All K&E drafting media give you excellent erasability, but there's a right way to erase on each one. On cloth and film, harsh, gritty erasers can destroy the surface. You'll get the best results with plastic erasers, such as the Richard Best "Tad" and the Eberhard Faber "Race Kleen." Moisten them for removing ink and stubborn typing; use them as they are for removing pencil lines. Large areas of ink can be removed completely without damage by using a moist cloth and Bon Ami cleanser. On Albanene, electric erasing machines are fine if used with a soft eraser.

The Choice Is Up To You

When it comes to selecting K&E paper, cloth or film for the job at hand, we have to leave the choice to you. We're not being indecisive . . . it's just that you're the only one who knows the particular problem you have and which product solves it best. But remember . . . K&E has a *complete* line of paper, cloth and film . . . and only K&E puts a special "engineered surface" on all three media to provide a well-balanced, uniform surface suited to the base material.

KEUFFEL & ESSER CO., Dept. SJ-4, Hoboken, N. J.

Please send me more information and samples on the following:

☐ K&E Herculene ☐ K&E Albanene ☐ K&E Phoenix

Name & Title_____

Company & Address_____

_____ 1277

Lucky Stores, Inc., relies heavily upon Diesel-engined White-Freightliner COE Tractors for dependable transportation of goods to its 110 supermarkets. All of Lucky's Freightliners are equipped with Fuller R-96 ROADRANGER Transmissions.

Geared by FULLER . . .

Lucky STORES eliminates transmission maintenance problems

"A truck failure during a run in the desert heat would mean a loss of thousands of dollars worth of fresh produce," says Joseph F. Schaeffer, Vehicle Maintenance Superintendent for Lucky Stores, Inc., San Leandro, California.

Because the huge supermarket chain trucks more than $100 million worth of foodstuffs a year to its 110 modern stores, Lucky has instituted a comprehensive preventive maintenance program and has been careful to purchase efficient, reliable equipment.

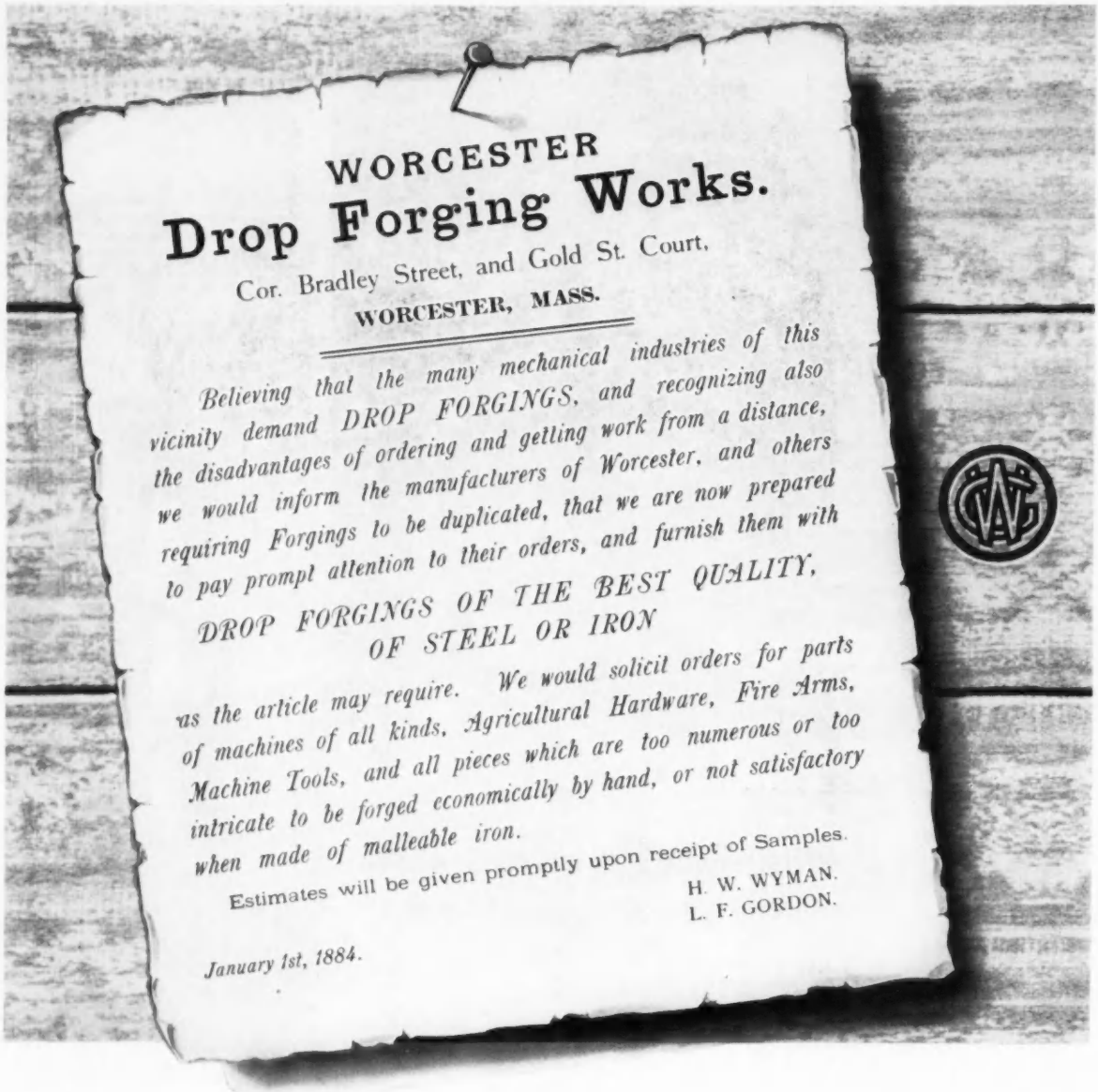
Backbone of the Lucky Stores fleet are Diesel-powered White-Freightliner COE Tractors, all of which feature 10-speed, semi-automatic Fuller R-96 ROADRANGER® Transmissions. Experience with these transmissions, together with Fuller 5-A-65 Transmissions in Lucky's White WB-28T Tractors, has been exceptionally satisfactory.

Mr. Schaeffer says, "We haven't had a main box down in the last five years. We're going to standardize on the ROADRANGER for diesel and gasoline tractors in the future. Our drivers like them and we are having no maintenance problems whatsoever."

Ask your truck or equipment dealer about the Fuller Transmission designed to put more profit into *your* particular operation.

FULLER — *TRANSMISSION DIVISION* — **MANUFACTURING COMPANY**
KALAMAZOO, MICHIGAN
Subsidiary EATON Manufacturing Company

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla. Automotive Products Company, Ltd., Brock House, Langham Street, London W.1, England, European Representative



Reproduced above is the formal announcement made January 1, 1884 of the partnership formed a few weeks previously in November of 1883 and known as the Worcester Drop Forging Works, later to be incorporated as Wyman & Gordon.

Today, after seventy-five years, Wyman-Gordon is still "prepared to pay prompt attention" to *your* orders and to furnish "forgings of the best quality," not only of steel, but of light alloys and all of the new exotic heat-resisting materials including beryllium.

And through the years Wyman-Gordon has continued to concentrate on one product—forgings; and one standard of quality and service—the best.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM
Also Beryllium • Molybdenum • Columbium and Other Uncommon Materials

WORCESTER 1, MASSACHUSETTS
HARVEY, ILLINOIS • DETROIT, MICHIGAN

Trailer constructed of corrugated, strong, nickel-containing stainless steel on top and sides, polished stainless front and rear, has modern good looks. Gives extra years of low-upkeep service. Made by Fruehauf Trailer Company.

Put more sell into trailers with stainless steel

See what you can do with nickel-containing stainless steel to boost cargo space ... service life ... appearance

Look into the dollars-and-cents advantages you can put into trailers with nickel-containing stainless steels:

High strength permits use of lightweight, thin-gauge sections for:

(1) more payload – trailer is stronger, not heavier.

(2) more inside space – wall bracing is compact.

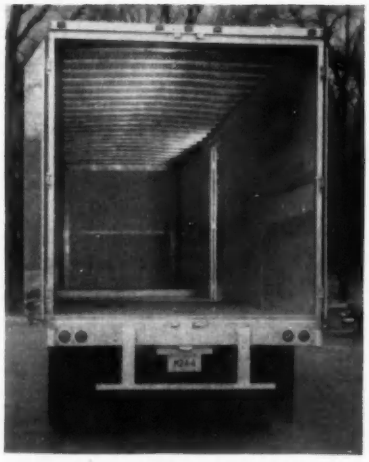
Corrosion resistance gives:

(1) long service life – resists storm, spillage.

(2) low upkeep – no painting needed; cleans easily.

There are other advantages—tough, hard, nickel-containing stainless steel provides exceptional durability – it's harder to scratch or damage. The corrugations give the unit additional longitudinal strength, rigidity.

You'll likely find several more ways to use low-upkeep, durable, nickel-containing stainless steels. For latest information on these versatile metals, write Inco:



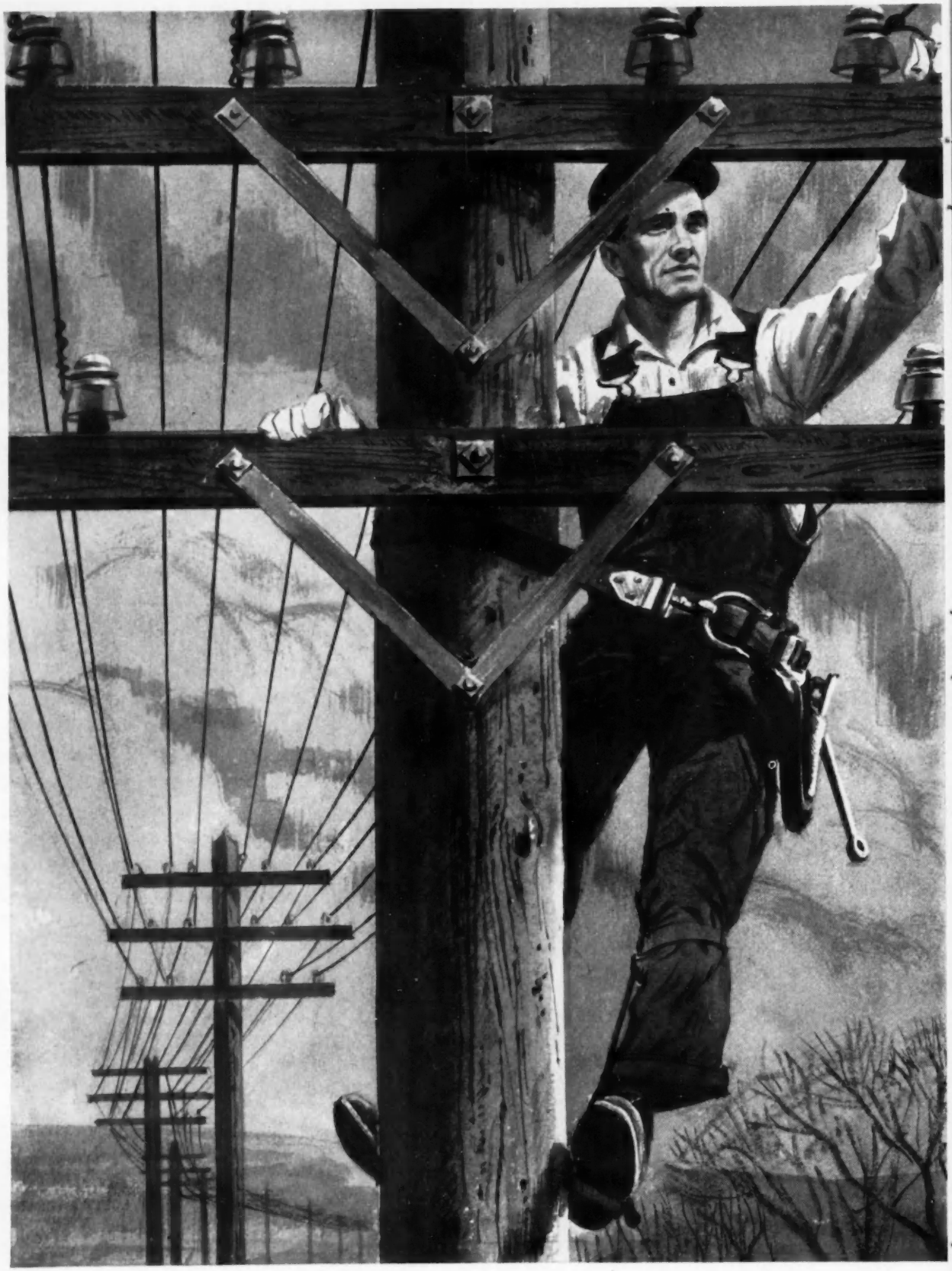
Rear view, showing corrugated stainless steel roof and bows.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

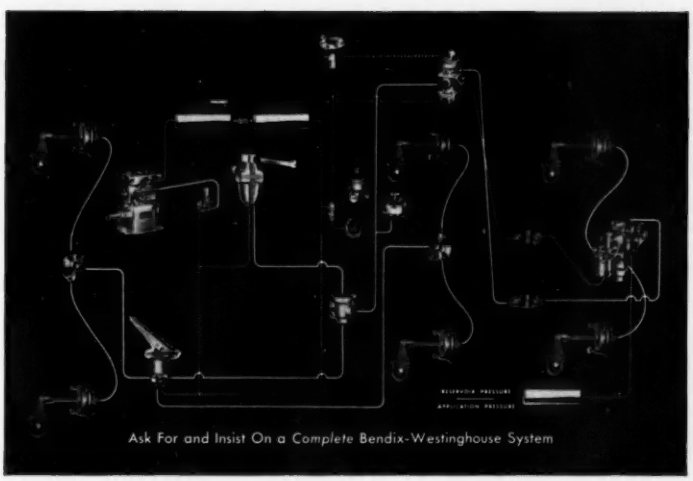
NICKEL MAKES STAINLESS PERFORM BETTER LONGER



Dependable systems demand systems planning and engineering

It's true with communications systems and it's equally true with air brakes. For peak performance, both systems depend upon operating compatibility of a wide variety of precise and interrelated devices. In *any* system you can, of course, buy one component here, another component there, but to get the most efficient, most reliable, most economical performance you need a *complete* chain of components, or devices, each system-engineered to do a specific task with predetermined accuracy.

You buy such a chain when you specify *complete* Bendix-Westinghouse Air Brake Systems for your vehicles. You get top performance for a longer period and at lower over-all cost. It's one more reason why it pays to specify Bendix-Westinghouse Air Brakes . . . *complete* air brake systems for which we accept full and complete responsibility. Fleet operators know this. And that is why more vehicles travel more miles with Bendix-Westinghouse Air Brakes than with all other air brakes combined.



Ask For and Insist On a *Complete* Bendix-Westinghouse System

SYSTEM — according to Webster: "Many parts connected in such a manner to create a chain of mutual dependencies".

Bendix-Westinghouse

AUTOMOTIVE AIR BRAKE COMPANY

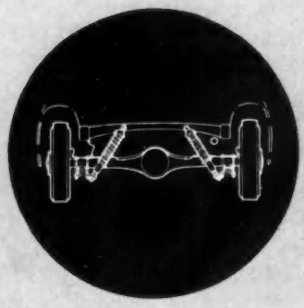
General offices and factory—Elyria, Ohio. Branches—Berkeley, Calif. and Oklahoma City, Okla.

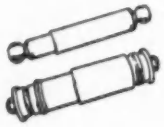
LOAD-LEVELERS*

—Monroe stabilizing units with built-in ride control for a level ride under all road and load conditions

- ✓ **Do the work of elaborate suspension systems —at a fraction of the price.**
- ✓ **Prevent "tail drag", side sway, and "bottoming" on axles.**
- ✓ **Prevent hard steering and excessive tire wear.**
- ✓ **Require no service, and don't interfere with under-body servicing.**
- ✓ **Easily installed as optional equipment at factory or car dealers.**

TYPICAL INSTALLATION: Monroe Load-Levelers are installed in exactly the same position and on the same mountings as the rear shock absorbers. They automatically compensate for all road and load conditions, provide maximum stability.





MONRO-MATIC SHOCK ABSORBERS—Standard on more makes of cars than any other brand.

DIRECT ACTION POWER STEERING—The only truly direct-action Power Steering units available.

MONROE SWAY BARS—Specified as standard equipment on 15 makes of passenger cars.

E-Z RIDE SEATS—Standard on more tractors than all other seats of this kind combined.

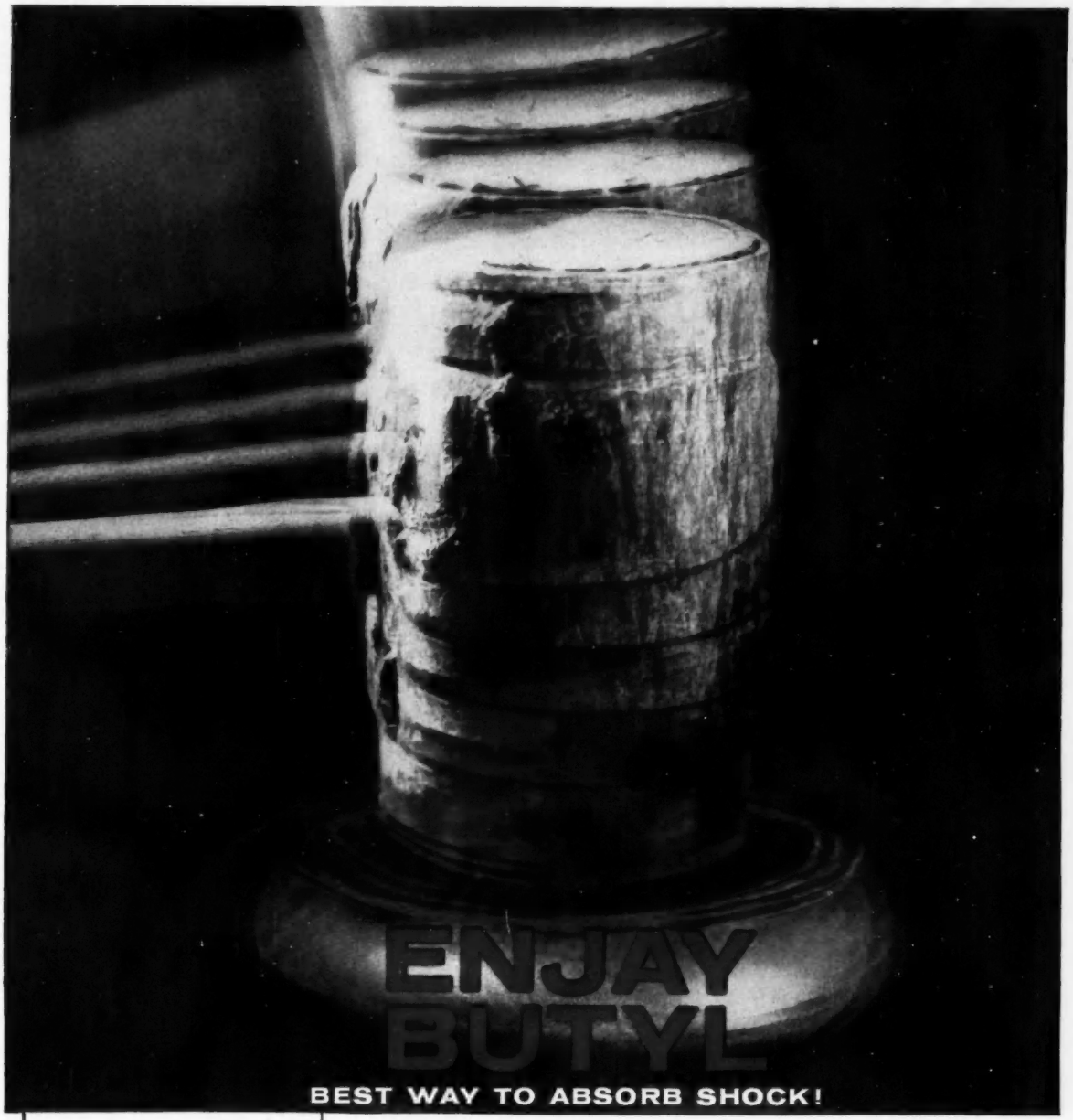
MOLDED RUBBER PRODUCTS—Precision-built for all automotive and industrial applications.

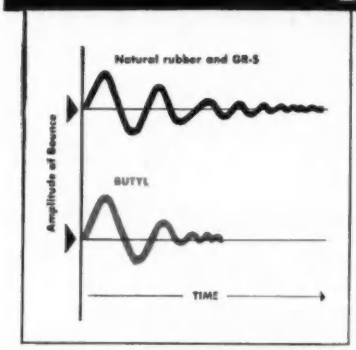
MONROE AUTO EQUIPMENT COMPANY, Monroe, Michigan

In Canada • Monroe-Acme, Ltd., Toronto

MONROE *World's largest maker of ride control products*

*Trademark





Butyl's superior shock absorption characteristics reduce amplitude of bounce in much less time as compared with other rubbers.

Enjay Butyl, because of its higher damping factor, absorbs shock energy *more* completely than any other rubber. Through simple variations in compounding or processing, you can build the right degree of resiliency for your requirements. Butyl is the ideal rubber for motor mounts, load cushions, sound deadener insulation, axle and body bumpers—and other shock, noise and mechanical vibration applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . heat . . . abrasion, tear and flexing . . . unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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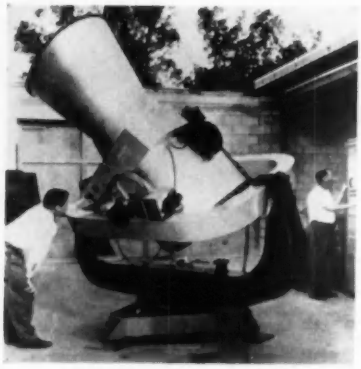
THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

HOW TO TAKE A SNAPSHOT OF A SATELLITE IN FLIGHT

If snapshooting satellites is on your agenda, contact either Boller & Chivens/-Joseph Nunn, South Pasadena, California, or the Perkin-Elmer Corporation, Norwalk, Connecticut.

In collaboration, these two firms make just what space photographers need. It's called the IGY Satellite Tracking Camera. And, of necessity, it's somewhat larger than the cameras most of you are accustomed to using. Like this.



Twelve of these cameras are now in use around the world. Each is designed to, first, take a picture when fixed on and following the *satellite*. This renders the subjects as a point against a background of streaks from the brightest stars. Then a second exposure is taken with the camera fixed on and moving with the *stars*. This provides the reference for determining the satellite's location.

And us? We provide the mirror blanks for Perkin-Elmer, who in turn handle the complete optical system. (The West Coast firm provides mechanical components and does the assembling.) The blanks we furnish are $31\frac{3}{4}''$ in diameter and $7''$ thick. They are made from glass No. 7160, the very same glass used in casting the now-famous, 20-ton, $200''$ disc for the Mt. Palomar Observatory.

The big advantage in using this particular glass is its very low linear coefficient of expansion—23×10^{-7} per ° C. Low expansion means a minimum of distortion, a much-appreciated contribution in the complex optics called for in taking pictures of satellites.

These king-sized mirrors lead us quite naturally to remind you that *Corning can do almost anything with glass*. Find out for yourself. Get a copy of "This Is Glass." Use the coupon for quick service.

NEW GIANT GLASS FLASK FOR THE IN-BETWEEN TASK

What intrigues the man in the picture is the *size* of the crystal clear vessel he is examining.

His interest is justified because as far as we know this is the *biggest* all-glass reaction flask on the market. It's new; it measures 18 inches in OD and stands 26 inches high. Capacity is 20 gallons.

We provide this size—along with 5 and 10-gallon versions—for people (maybe you) who need to fill the gap between lab and pilot plant.

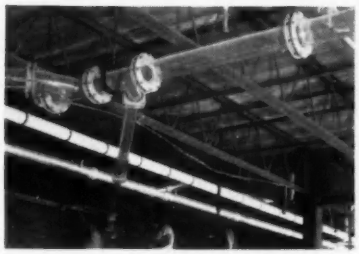
You also can get all the trimmings. Like the five-opening all-glass cover that's visible behind the flask. Such covers can be had with pipe flanges, ⅁, or socket joints. Accessories include inlet tubes, condensers, blind caps, clamps and thermometer wells. Need one? Just write for details.

This outsized glassware is all made from PYREX brand glass No. 7740—a glass that performs admirably because of the virtues detailed elsewhere on this page.

Which brings us to this diminutive and relatively intricate container known as a Warburg flask. It's quite commonplace to biochemists who use it for measurement of cell respiration and tissue metabolism. It's also a stock item with us.

We call the big ones and the little ones *both* to your attention because it points up the fact that size or shape is a consideration—*not* a limitation—to the skilled glassworkers at Corning.

Investigate by tossing us any one of your tough problems. We'll look for a glass answer and let you know soon what we can do.



PLUMBING FOR POSTERITY

An increasingly popular fixture in labs, hospitals, schools, chem plants, and photoengraving shops is the glass drainline.

With good reason. Glass drainlines are fashioned from PYREX brand glass No. 7740.

This is the glass that ends your worries about corrosion. For example, if you were disposing of waste hot hydrochloric acid, your PYREX pipe would still be around at the end of 200 years.

And glass is smooth; very little chance for block-up in the pipe. If such does occur, however, you can spot the exact point and take corrective action, without having to take down the whole system.

In fact, almost anything made from PYREX brand glass No. 7740 will be around for quite a while because this glass is able to cope with thermal shock and physical knocks, too.

Available in many forms—tubing, rod, pipe, plate, and all kinds of shapes.

Fill in the gaps in your files with these basic references: PE-30, all about glass drainlines; IZ-1, design considerations in glass. Any or all, free. Use the coupon.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 40 Crystal Street, Corning, N.Y.

Please send me; ☐ "This Is Glass"; ☐ Drainline Manual, PE-30; ☐ Design Manual IZ-1; ☐ Info on Reaction Flasks

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During our more than 45 years of service to the Automotive Industry, parts by "Cleveland" have served and are still serving many manufacturers whose products have won world-wide acclaim. We are proud of the part we have played in their success and proud of the reputation for reliability and ruggedness which "Cleveland" parts have won with our manufacturing customers.

When looking for component parts you can depend on, it pays you to come to "Cleveland." We will welcome the opportunity to work with you.

Cleveland Steel Products Corporation

Automotive Division

16025 Brookpark Road • Cleveland 11, Ohio

Hepolite for high performance thoroughbreds

Photograph by Telegraph & Argus, Bradford.

The David Brown Aston-Martin DB.4 is a thoroughbred of the car world, turning the heads of all who see its elegant design and witness its phenomenal performance. We feel justly proud that Hepolite products play an important part in setting the DB.4 at the head of the field. For many years we have supplied components to this famous stable, gaining vast experience in the design and manufacture of pistons, gudgeon pins, and cylinder liners of the highest quality. The same high standard of craftsmanship and precision engineering goes into all our products for both the manufacturing and replacement trades.

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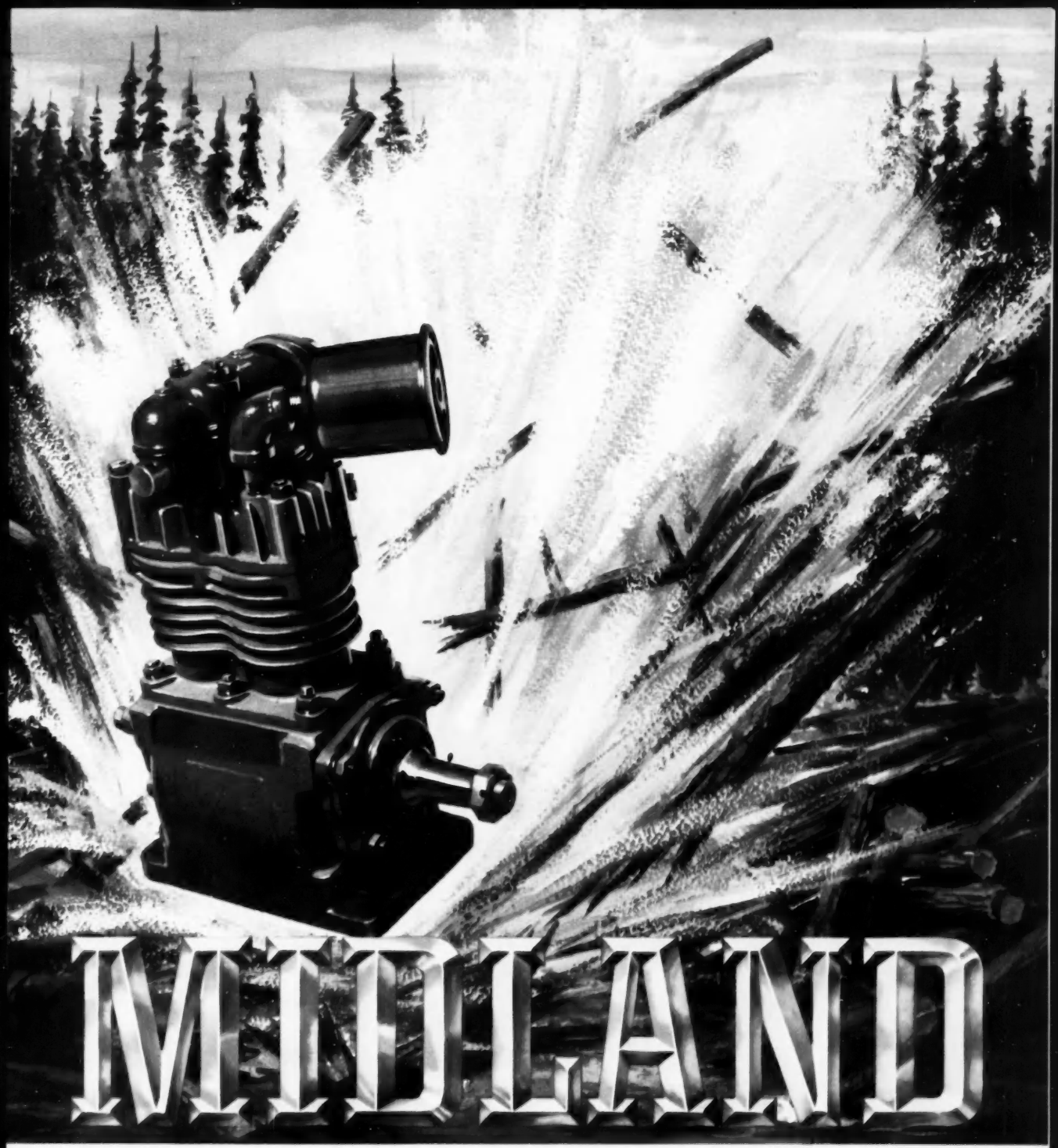
Established for over 50 years :— There is no substitute for experience



MIDLAND COMPRESSOR – Heart of Midland Air Power Systems

Midland products include:

Air brakes for the truck and trailer industry
Vacuum power brakes for the automotive industry
Equipment for the Transit industry
Control devices for the construction industry
Midland Welding Nuts for assembling metal parts

Write for detailed information

MIDLAND-ROSS CORPORATION

Owosso Division • Owosso, Michigan

ONE OF THE "400" LARGEST AMERICAN CORPORATIONS

NEW

TUNG-SOL 536

Two-Terminal HEAVY DUTY FLASHER

Replaces the standard

two-terminal flasher

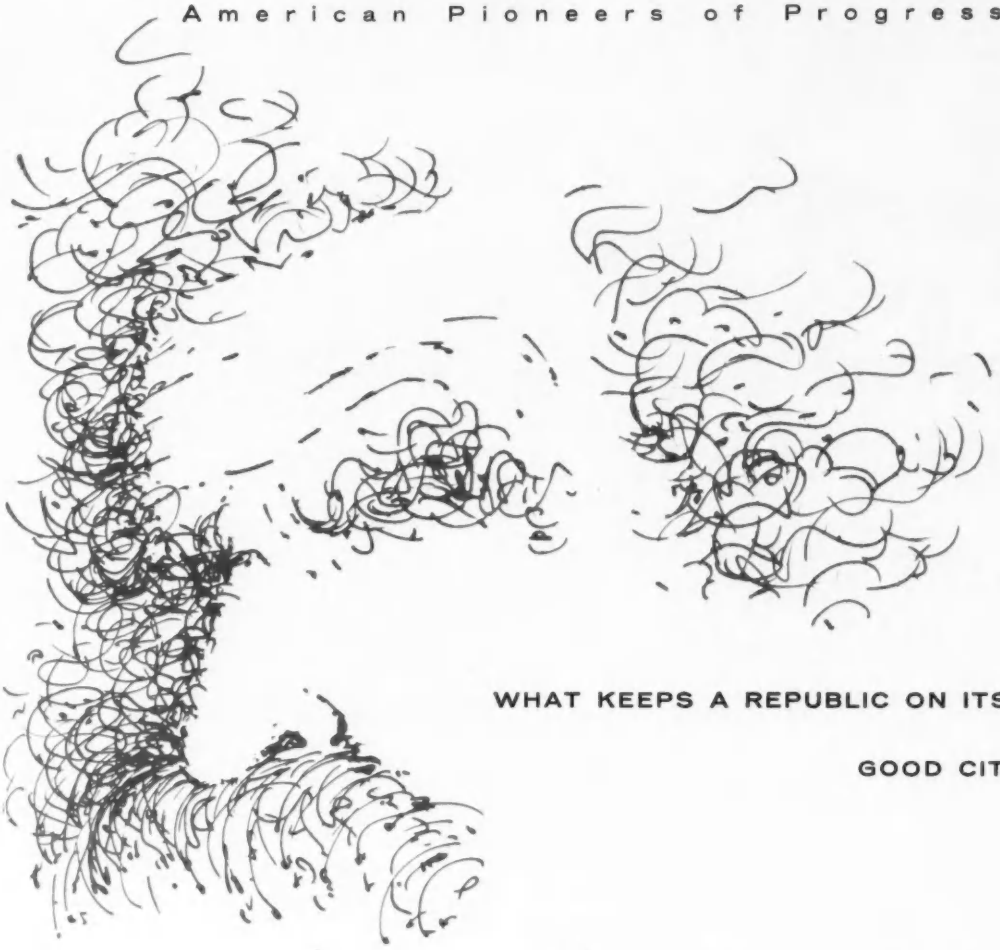
Like the three-terminal 534 and 535, it's built with twice the life of other flashers

For the first time . . . a two-terminal heavy duty flasher that meets the requirements of the biggest part of the truck market as well as the vast majority of passenger car trailer applications — U-haul, boat and house trailers.

The new Tung-Sol 12-volt 536 is identical in performance with the 534 three-terminal type: It flashes one to six 21cp or 32cp lamps without a perceptible change in the flashing rate . . . delivers an instantaneous four-lamp emergency warning . . . lasts twice the life of other flashers . . . insures more positive action and great dependability. Electroswitch Division, Tung-Sol Electric Inc., Newark 4, New Jersey

TUNG-SOL® — *First in Flashers*

American Pioneers of Progress



WHAT KEEPS A REPUBLIC ON ITS LEGS IS

GOOD CITIZENSHIP

Mark Twain

CARTER CARBURETOR

DIVISION OF acf INDUSTRIES, INCORPORATED

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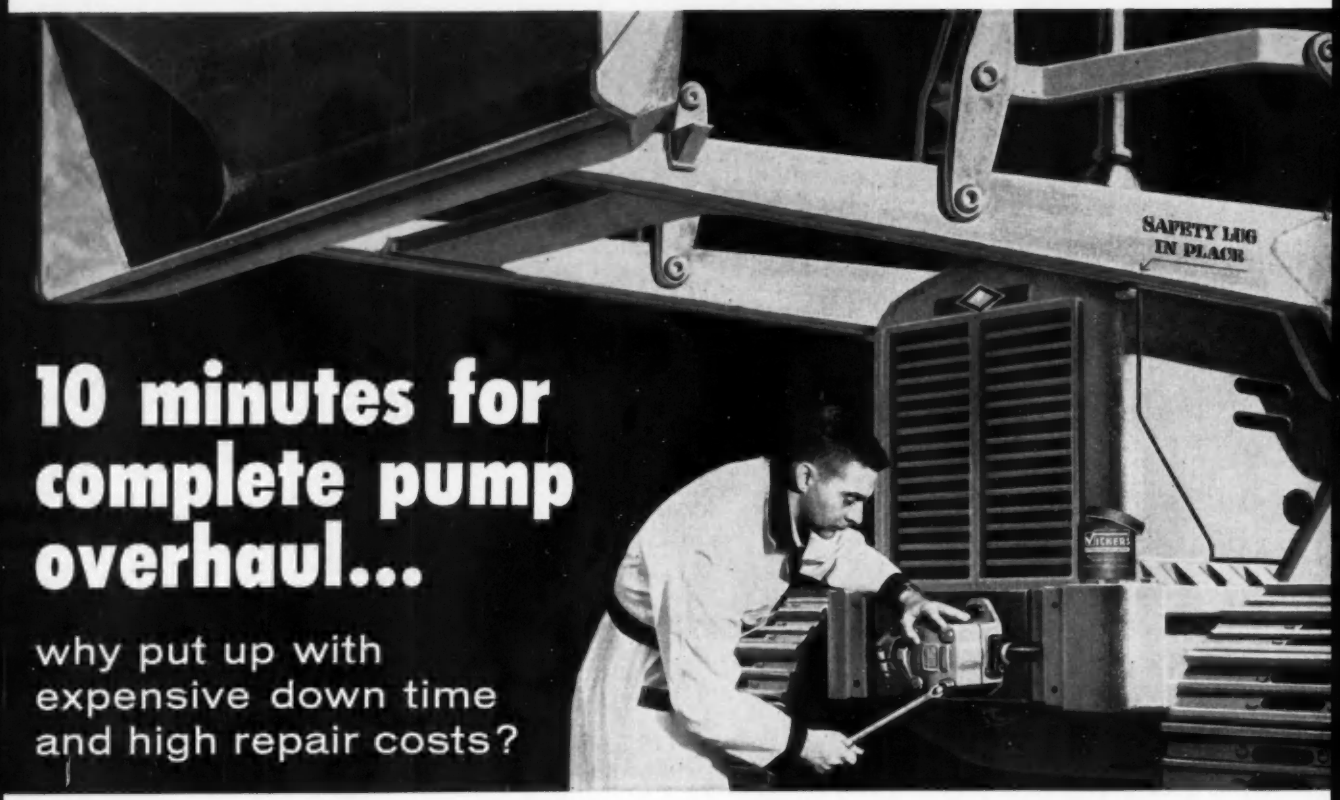
50 FIFTY YEARS OF ENGINEERING THE FUTURE



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot maintenance with

VICKERS®

"High Performance" Pumps*
keeps your jobs on schedule

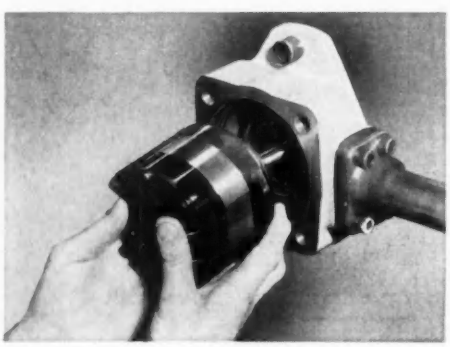
*PATS. & PATS. PENDING

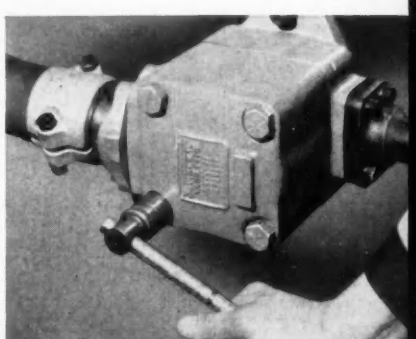
Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.





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Series L6N-L6S Needle bearings or sleeve bushings. For moderate pto hp or steering jobs.

Series K With sleeve bushings. For hand controls and pto service.

These grader builders offer steering smoothness — plus ROCKWELL-STANDARD QUALITY

with BLOOD BROTHERS Universal Steering Joints

Certainly, graders get their share of steering shocks and strains. And the engineers who design them expect it.

That's why grader builders so often furnish Blood Brothers Universal Steering Joints. From start to finish, they're soundly designed and ruggedly built to stand punishment.

Contractors can appreciate their steering smoothness and freedom from trouble. Design Engineers can depend on Rockwell-Standard's high level of quality—and friendly cooperation in solving special problems.

If you're not already using Blood Brothers Joints, just write or call. Our engineers will gladly work with you.

For general information, write for Bulletin 557.

ROCKWELL-STANDARD CORPORATION

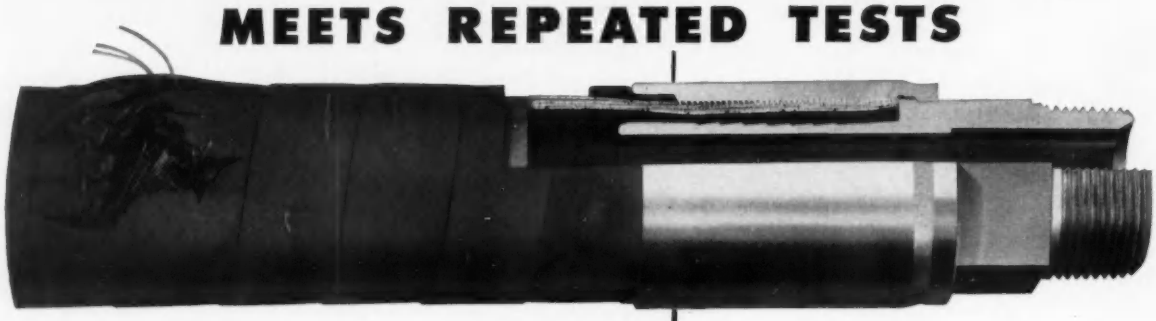
ROCKWELL R STANDARD BB UNIVERSAL JOINTS

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form *a bond which was stronger than the hose itself.*

If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

Eastman
first in the field

MANUFACTURING COMPANY
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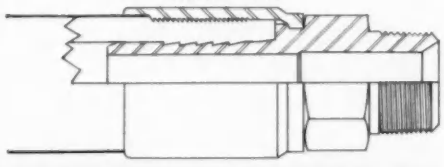
WRITE today for your copies —

Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

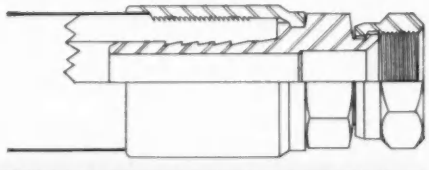
Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.

MALE NPTF



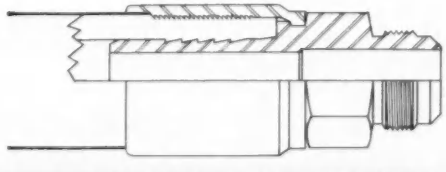
Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12M	¾	1 7/16	19/32	20,000	5,000
8416-16M	1	1 ¾	25/32	16,000	4,000
8420-20M	1 ¼	2	1 5/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 21/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12FH	¾	1 7/16	19/32	20,000	5,000
8416-16FH	1	1 ¾	25/32	16,000	4,000
8420-20FH	1 ¼	2	1 5/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 21/64	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12MH	¾	1 7/16	19/32	20,000	5,000
8416-16MH	1	1 ¾	25/32	16,000	4,000
8420-20MH	1 ¼	2	1 5/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 21/64	10,000	2,500

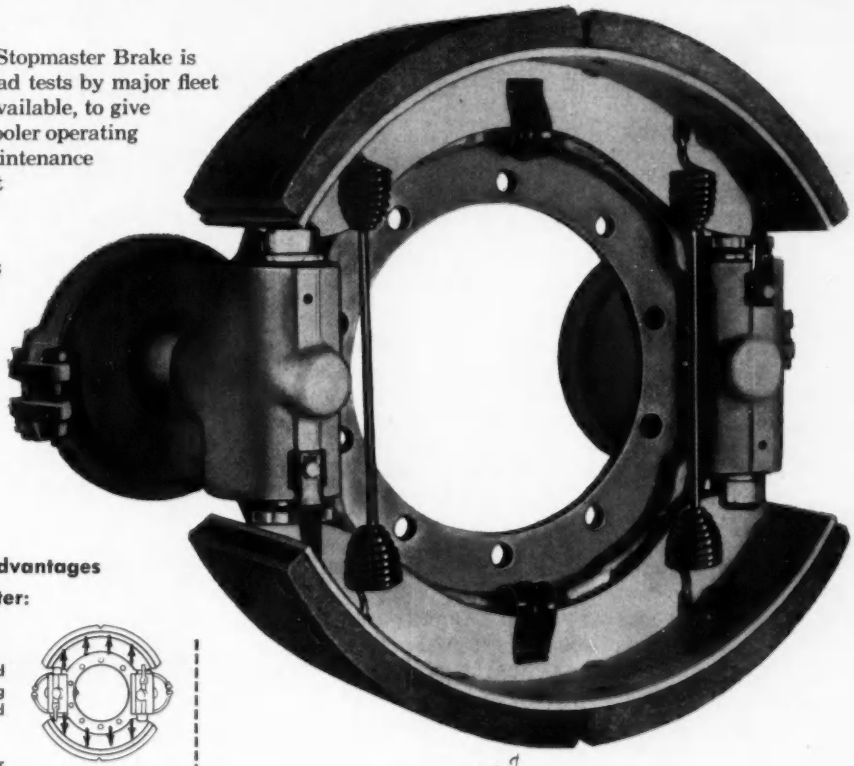
leading fleet operator road tests are proving...

THE NEW STOPMASTER BRAKE

the most advanced new brake design in 30 years!

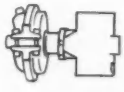
Rockwell-Standard's new Stopmaster Brake is now undergoing rugged road tests by major fleet operators. It will soon be available, to give you faster, surer stops . . . cooler operating temperatures . . . lower maintenance costs . . . and lighter weight for greater payloads!

Greatly improved performance characteristics of the Stopmaster permit standardization on a single brake diameter for a diversified line of vehicles. It will be offered in a 15" diameter for highway vehicles and in various widths.

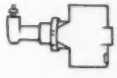


Just A Few Of The Many Advantages Of The New Stopmaster:

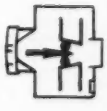
Balanced Shoe Action, in both air and hydraulic designs, gives uniform lining wear, increased drum and lining life and reduced bearing stress.



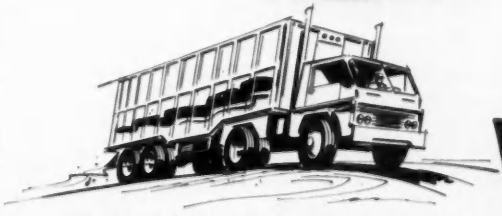
Close Coupled, Compact Unit for greater ease of mounting. New-design air actuators are mounted directly to the supporting member of the brake assembly, reducing vulnerable outrigging and improving road clearance.



Greater Heat Ranges possible with hydraulic brake due to new design external wheel cylinders. This means full braking performance at higher operating temperatures, without boiling of brake fluid or damage to rubber wheel cylinder parts.



New Stopmaster Actuation Principle offers new standards of efficiency over conventional designs. Assures uniform braking performance in both single or dual actuator units.



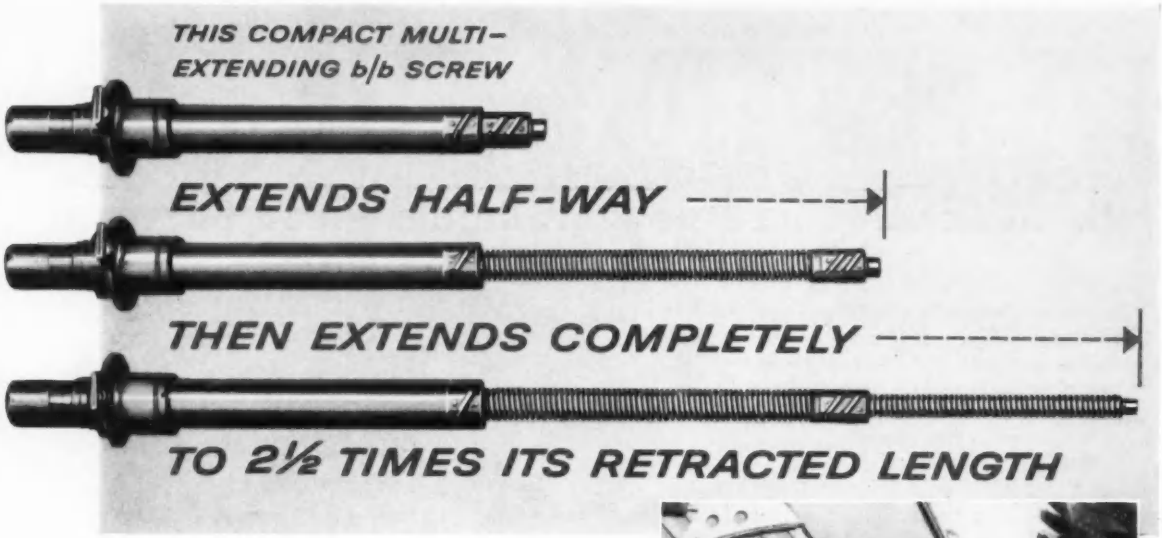
ROCKWELL R STANDARD

ROCKWELL-STANDARD
CORPORATION

BRAKE DIVISION Ashtabula, Ohio

Brakes for every industrial, agricultural or automotive application where braking is required!

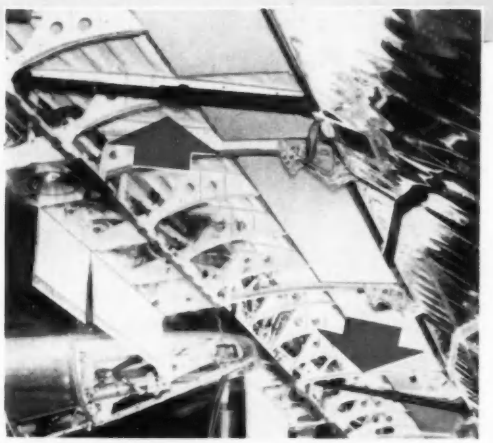
FAR-REACHING EXTENSION FROM LIMITED ACTUATOR SPACE



Now Saginaw supplies the answer to your most difficult actuator space problems with the Multi-Extending Saginaw Screw! Utilizing Saginaw's time-proved *recirculating ball* principle in multiple telescoping sections, the Multi-Extending b/b Screw conquers actuator space obstacles designers have been seeking to overcome for years! Here's why:

1. **UNIT EXTENDS** in a ratio of 2.5 to 1, providing maximum extension 2½ times the length of the retracted screw.
2. **FAR GREATER LOAD CAPACITY** than any other telescoping device in its class.
3. **FAR MORE PRACTICAL AND TROUBLE-FREE** than other telescoping units on the market.
4. **PRECISE, DEPENDABLE POSITIONING** and control within thousandths of an inch.

• OVER 90% EFFICIENCY • REQUIRES UP TO 4/5 LESS TORQUE than acme screws • LESS DRAIN on power supply • CONSERVES SPACE AND WEIGHT • OPERATES DEPENDABLY at extreme temperatures • PERFECT FUNCTIONING with only initial lubrication



USED ON THE COUNTRY'S MOST MODERN AIRCRAFT—Multi-Extending b/b Screw wing flap actuators being installed on the new Lockheed Electra.

The Saginaw Multi-Extending Screw is also used to actuate speed brakes, afterburners, variable air inlets, canopies and similar critical components on today's newest aircraft.

Send today for the new 1959 engineering data book on Saginaw b/b Screws and Splines... or see our section in Sweets Product Design File.

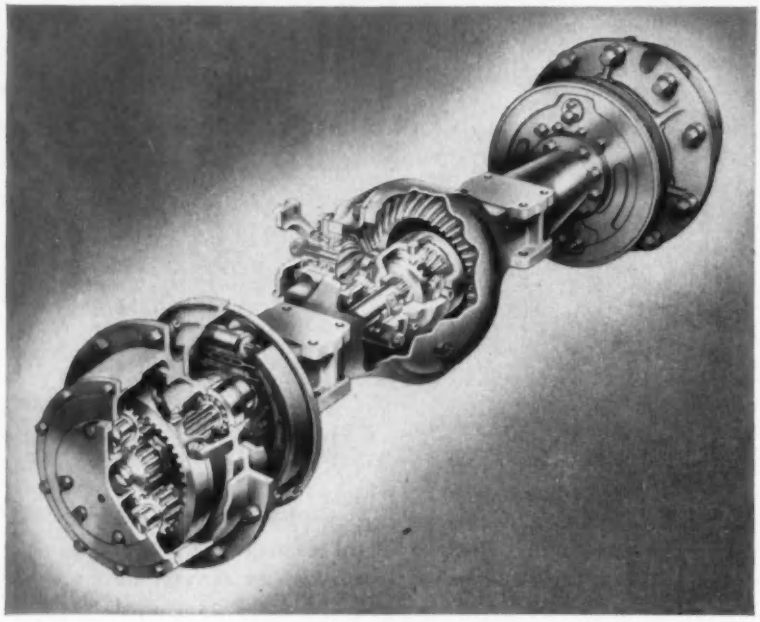
Saginaw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

ball bearing Screw

SAGINAW STEERING GEAR DIVISION, GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN

TORQUE TALK ABOUT CLARK® EQUIPMENT



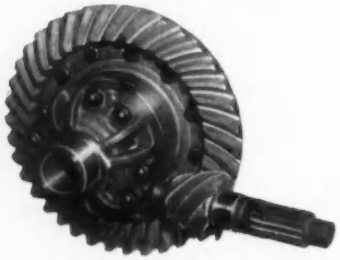
HOW TO PUT MORE POWER WHERE THERE'S WORK TO BE DONE

Horsepower and work loads are going up. More and more strains are being put on axle shafts. And more and more ordinary axles are breaking.

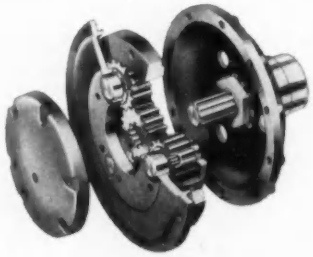
You can eliminate many of these troubles with Clark Planetary Axles.

These job-proved units by putting the final power reduction in the *hub*, take 70% of the torque load off the shaft. They virtually eliminate shaft windup and surge, cause of most broken axles.

If *you* run trucks, tractor shovels, dozers, scrapers or other heavy-duty on or off-highway vehicles, you will find it well worthwhile to get the facts on the complete line of Clark Planetary Axles—covering a range of capacities from 6500 lbs to 110,000 lbs—each a combination of maximum rugged strength with minimum size and weight.



PRIMARY REDUCTION in Clark Planetary Axles is in axle center section, by spiral bevel pinion and gear.



FINAL REDUCTION in hub, by sun gear splined to axle shaft. Ring gear is fixed; wheel is driven by three revolving planet gears.

Rugged Planetary Axles Available in Tandem, Too!

The same advantages you get with individual Clark Planetary Axles can also be yours with matched Clark Planetary Axles in tandem. Far less torque on axle shafts. Fewer broken axles. Stronger, lighter weight, in both on and off-highway rigs.

Moreover, with tandem Clark Planetary Axles, you eliminate massive axle shafts that twist and shear near differential splines. You cut deadweight, too; can haul more *payload*.

Clark Planetary Axles are now available in four sizes: from 28,000 lbs to 120,000 lbs ground loading capacity. All have through-type drive for minimum mounting height and additional overhead clearance. Equalizer beam and torque rods are rubber mounted, need no lubrication. Smaller axle banjo sections provide maximum under-axle clearance. Full floating types have housings designed for static loads imposed by crane carriers and other off-highway vehicles.

Get a smooth flow of power

Mobile or stationary, *any* power plant will do *more* work with *less* wear when connected to a Clark Torque Converter. These units provide a smooth flow of power, eliminate shock-loading, reduce wear on all parts of the power train and engine. There's a Clark size to fit your needs: 15 to 800 hp, 9 to 28 inch diameters.

FOR FURTHER INFORMATION...

and full details on any of Clark's automotive components, simply address a card or a call to:

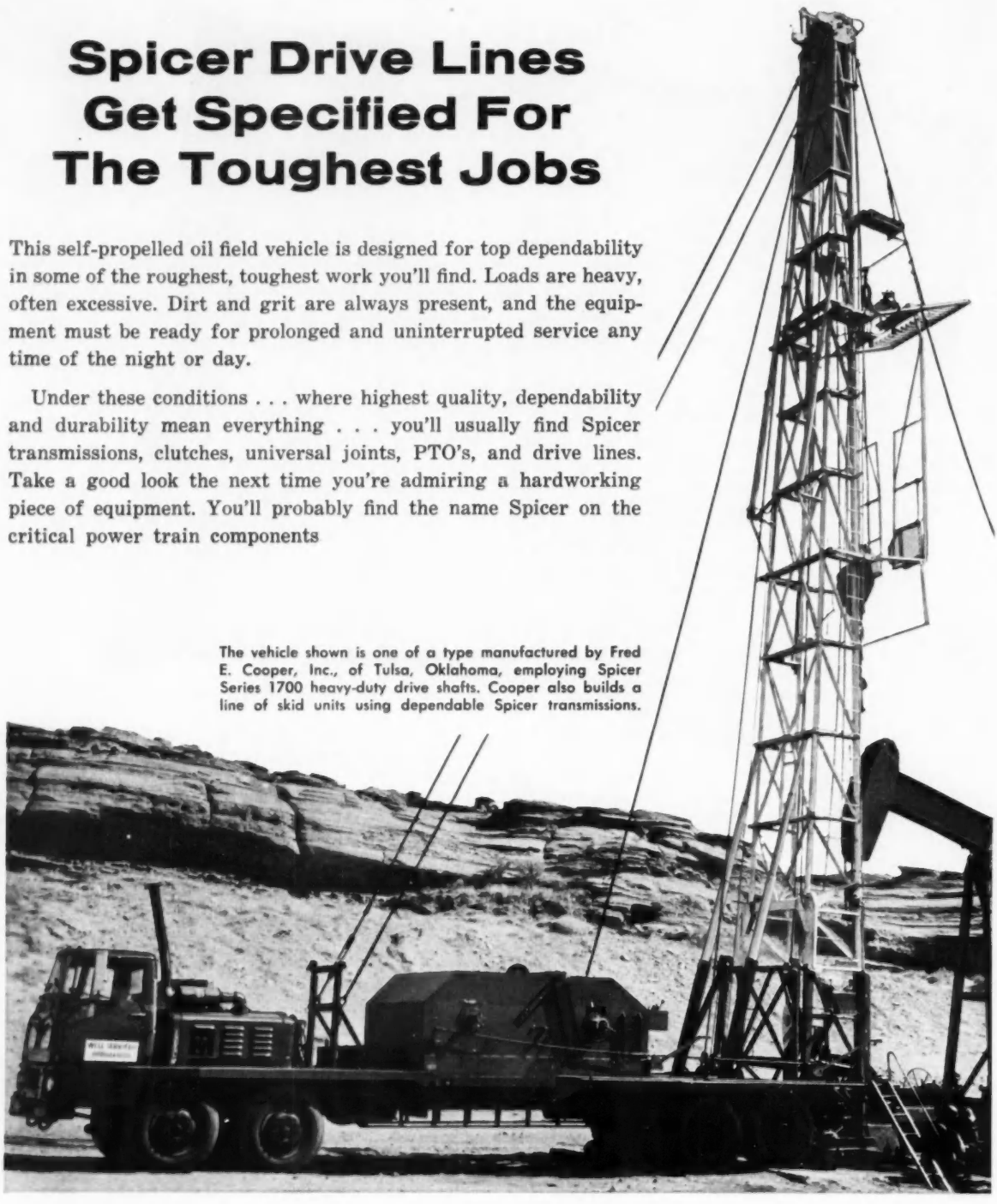
CLARK EQUIPMENT COMPANY
AUTOMOTIVE DIVISION
Buchanan 5, Michigan

Spicer Drive Lines Get Specified For The Toughest Jobs

This self-propelled oil field vehicle is designed for top dependability in some of the roughest, toughest work you'll find. Loads are heavy, often excessive. Dirt and grit are always present, and the equipment must be ready for prolonged and uninterrupted service any time of the night or day.

Under these conditions . . . where highest quality, dependability and durability mean everything . . . you'll usually find Spicer transmissions, clutches, universal joints, PTO's, and drive lines. Take a good look the next time you're admiring a hardworking piece of equipment. You'll probably find the name Spicer on the critical power train components

The vehicle shown is one of a type manufactured by Fred E. Cooper, Inc., of Tulsa, Oklahoma, employing Spicer Series 1700 heavy-duty drive shafts. Cooper also builds a line of skid units using dependable Spicer transmissions.



DANA Spicer

DANA CORPORATION • **Toledo 1, Ohio**

DANA PRODUCTS Serve Many Fields:

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Powr-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

INDUSTRIAL VEHICLES AND EQUIPMENT: Transmissions, Universal Joints, Propeller Shafts, Axles, Gear Boxes, Clutches, Forgings, Stampings.

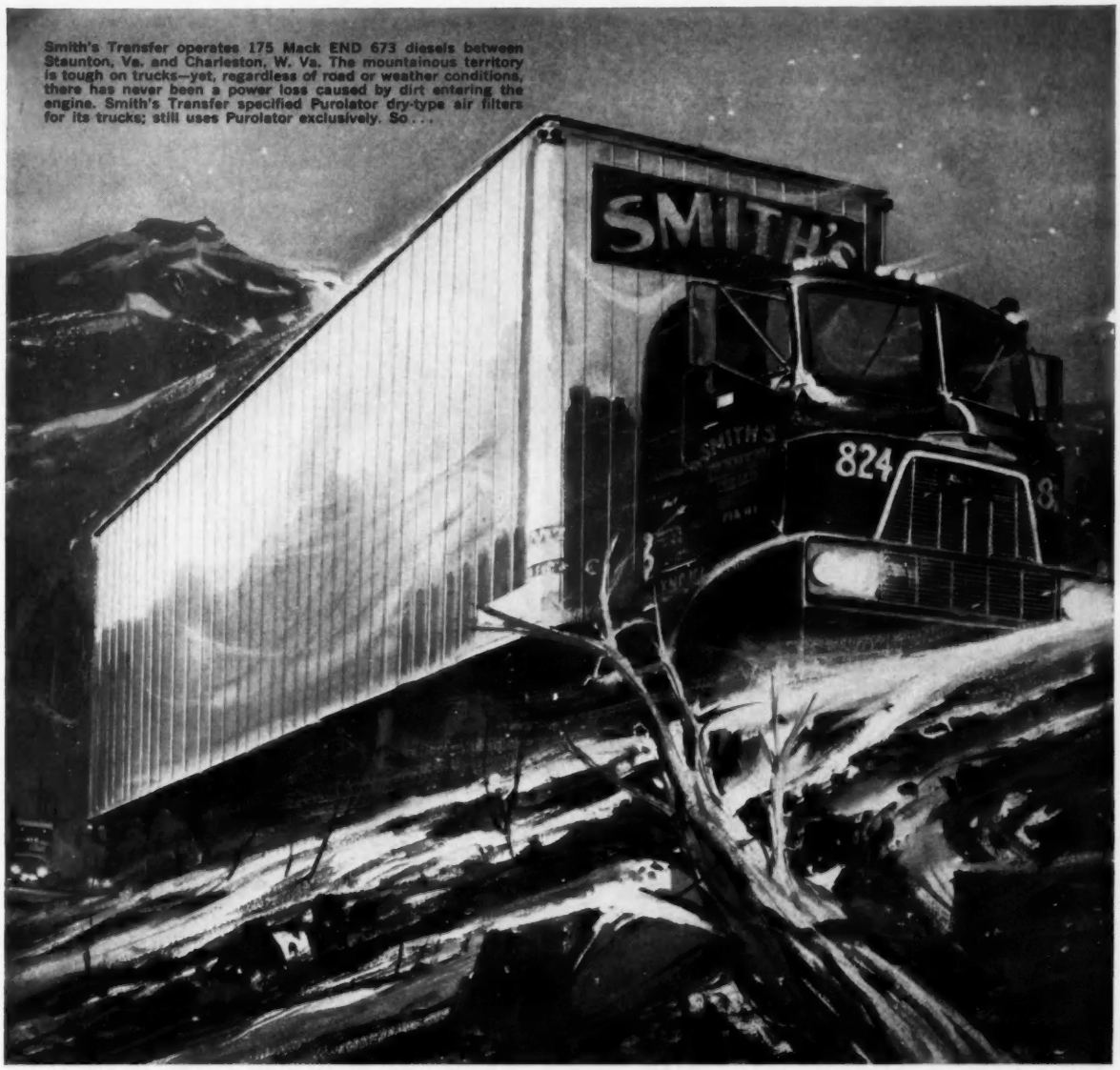
AVIATION: Universal Joints, Propeller Shafts, Axles, Gears, Forgings, Stampings.

RAILROAD: Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives, Forgings, Stampings.

AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario.



When your customers specify Purolator Air Filters there's good reason for it:

"The engines on our Mack diesels show no measurable wear on rings, walls or valves . . . even after 250,000 miles"

Merle W. Bogan, Service Manager, Smith's Transfer

Mr. Bogan always specifies Purolator because he realizes the importance of effective air filtration. He knows Purolator air filters prolong engine life, cut maintenance costs and reduce downtime to a minimum.

This is why you can be confident that any customer's specification is justified when, like Mr. Bogan, he insists on Purolator filters. What's more, you can confidently recommend Purolator dry-type air filters as original equipment in your own standard line of diesels.

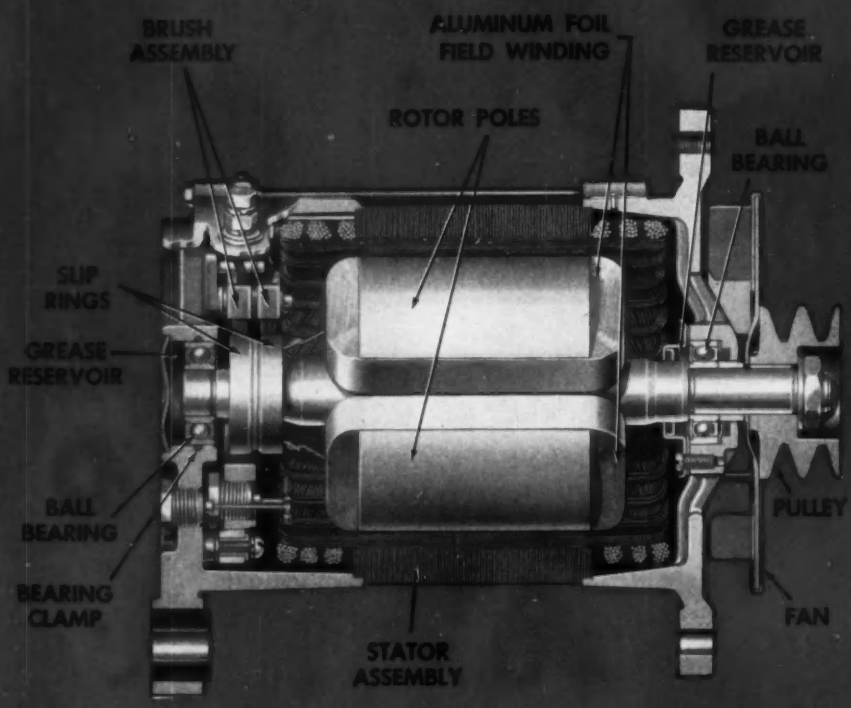
A Purolator engineer will be glad to present further details about the advantages and economies of Purolator filtration in the diesels you make. There's a Purolator filter designed to meet your requirements. Write or phone for full information – right now.

Filtration For Every Known Fluid **PUROLATOR**

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

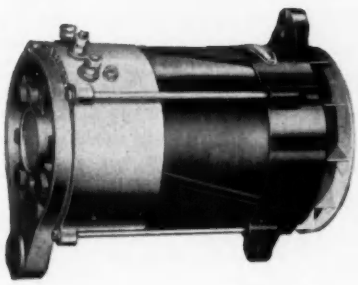
NOW! REAL CHARGE-AT-IDLE,

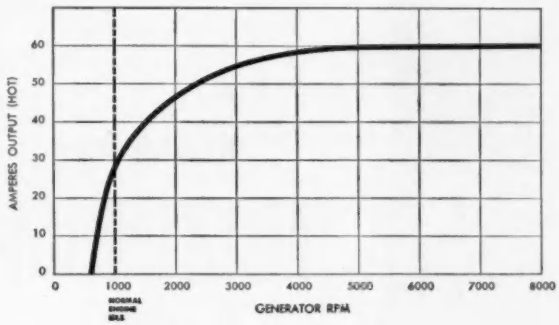


PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE

UP TO TWICE THE TOTAL OUTPUT

WHEN YOU REPLACE STANDARD D.C. EQUIPMENT WITH DELCO-REMY'S NEW SELF-RECTIFYING A.C. GENERATOR





Here's a completely new generator from Delco-Remy *specifically designed* to take care of cars and trucks with extra-heavy electrical loads under all traffic conditions . . . to increase battery life by eliminating deep cycling.

Designed to mount interchangeably with most standard d.c. generators, this compact new unit is only 5¾" in diameter and weighs just 31 pounds. The a.c. design eliminates commutation problems, providing extra-long brush life . . . and the ball bearings are "lifetime" lubricated so that no attention is required between engine overhaul periods. Six specially developed silicon rectifiers built into the end frame eliminate the need for space-consuming external rectifier units, reducing installation time and cost to a minimum.

Be sure to specify this new self-rectifying a.c. generator along with its companion transistor regulator (either full or transistorized model) on your new special-duty equipment for 1959. This all-new power team is still another example of Delco-Remy progressive engineering at work for you.

GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY—STARTING WITH Delco-Remy ELECTRICAL SYSTEMS

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

. . . performance beyond the usual . . .

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
- **Retainers of standard bronze or "Rollube" ferrous alloy, in roller-riding, land-riding, or broached construction**
- **Crowned rollers**
- **Modification of any factor to meet your application**

ROLLWAY

MAXIMUM

BEARINGS

To further implement your choice, the Rollway Catalog and Engineering Data Book contains the first listing, by any manufacturer, of the thrust capacities of cylindrical radial roller bearings.

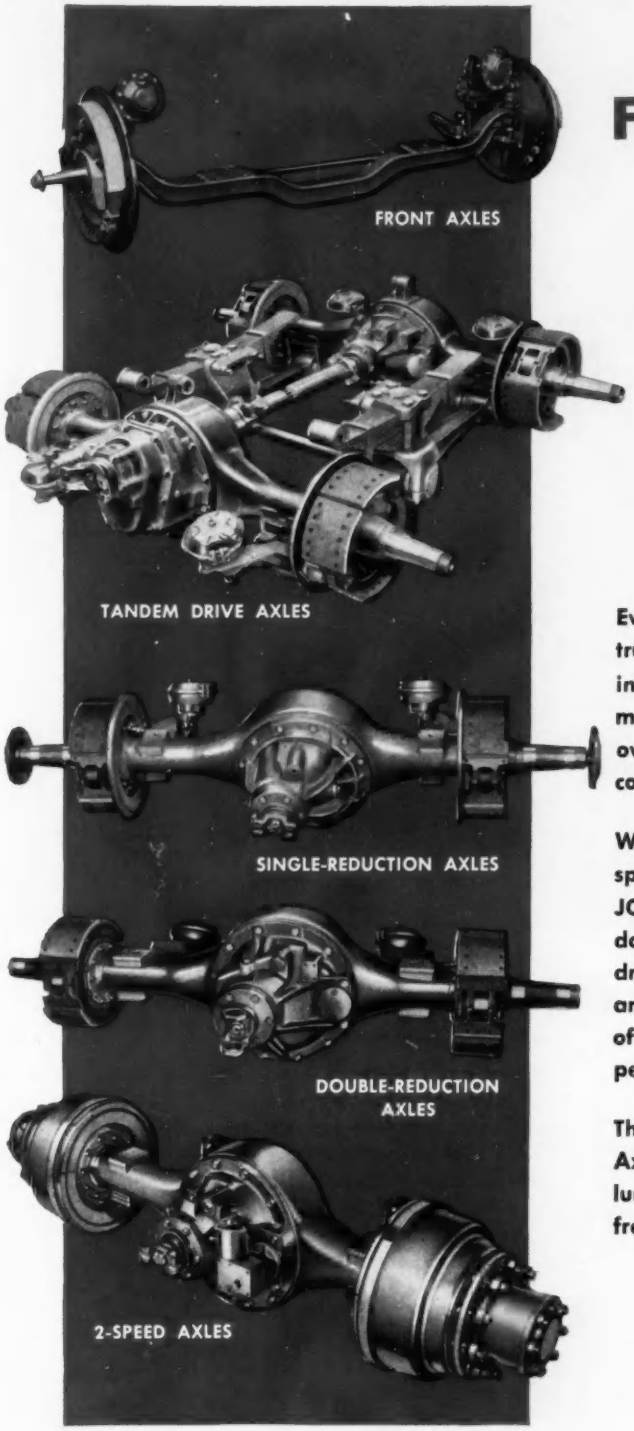
ROLLWAY BEARING CO., Inc., Syracuse 1, N. Y.

ENGINEERING OFFICES

Syracuse • Boston • Chicago
Detroit • Pittsburgh • Seattle
Cleveland • San Francisco
Houston • Los Angeles
Philadelphia • Toronto

ROLLWAY
Maximum
ROLLER BEARINGS

For Top Performance and Lowest Cost Per Mile—



It takes the RIGHT TRUCK for the Job—

★

and the RIGHT AXLE on the Truck!

There is a RIGHT AXLE in Eaton's Full Line of Types and Capacities

Every hauler knows how important it is to buy trucks that are RIGHT FOR THE JOB. Dollars invested for ample capacity and the right equipment to handle the job, are paid back many times over—in reduced maintenance, lower operating costs, and longer truck life.

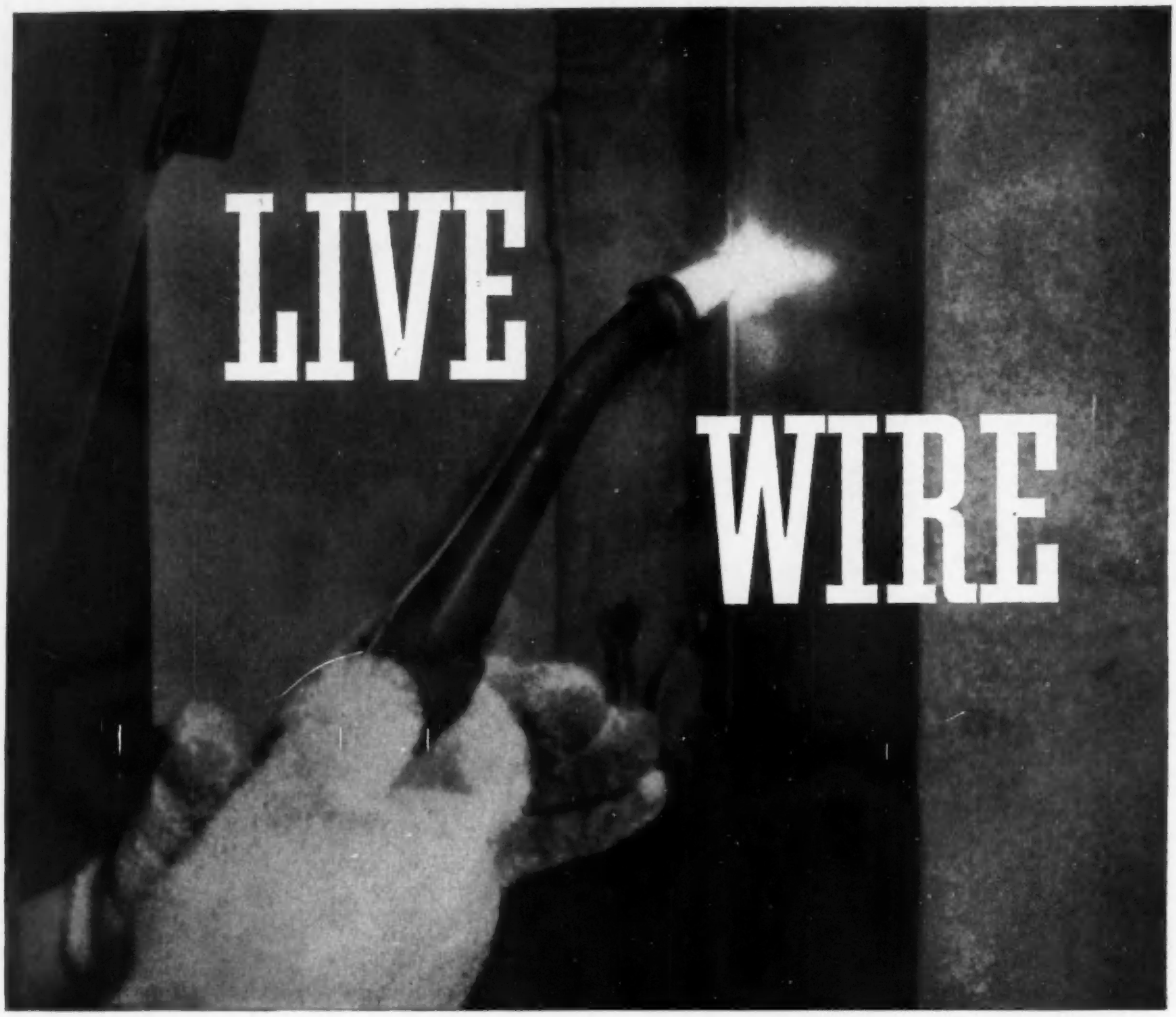
When a truck is purchased, it is important that specifications call for the RIGHT AXLE FOR THE JOB. The hauling job may call for single reduction, double reduction, or 2-speed—and perhaps tandem drive axles. There is an Eaton Axle of the right type and in the right size—backed by almost 50 years of axle manufacturing experience, and by proven performance in more than two million trucks.

Through research, engineering, and testing, Eaton Axles are continually improved in design and metallurgy to give haulers extra thousands of trouble-free miles without adding to weight or cost.

EATON

EATON

AXLE DIVISION
MANUFACTURING COMPANY
CLEVELAND, OHIO



New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service, a-c or d-c.

Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . distortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. SA4, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

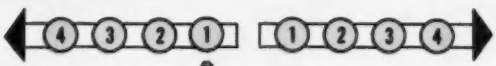
UNION CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

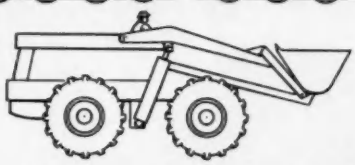
only the HYDRA-DRIVES® BDB

OFFERS ALL THESE MAJOR ADVANTAGES

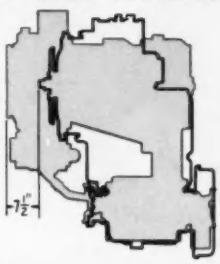
IN FULL-POWER SHIFT TRANSMISSIONS for equipment from 60 to 175 h.p.

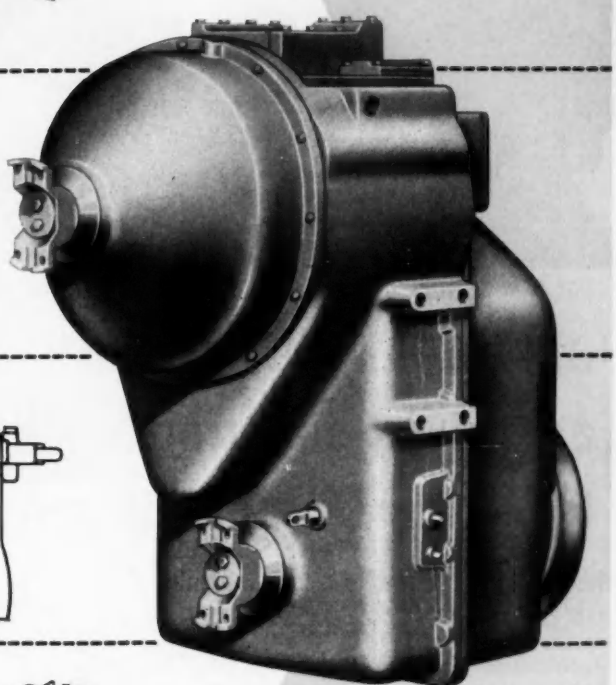


1. **4 speeds forward and reverse.** All power shifted! Provides maximum horsepower to load under all load conditions.

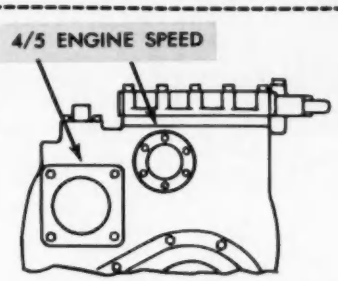


2. **Integral design.** Torque converter, transmission, oil passages, valving and oil sump are in one compact housing—7½" shorter than comparable models.

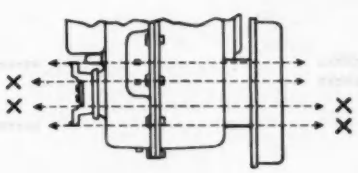




3. **Dual reduced speed pump drives.** Pumps can be driven at engine speed or 4/5 engine speed for longer life and increased horsepower to pump load. Single pump drive is also available.



4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



SPECIALLY DESIGNED FOR SMALLER INSTALLATIONS

Rockwell-Standard's new model Hydra-Drives Full Power Shift Transmission is now available in sizes especially designed for smaller installations, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles.

In addition, the Hydra-Drives BDB offers easier servicing and maintenance. There are fewer moving parts and bearings. The simple, rugged countershaft design and spur gears simplify maintenance.

HYDRA DRIVES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

Bill Adcock, Supt. of Motor Maintenance • RINGSBY TRUCK LINES, Inc., says:

"DIESELPAK CUTS ENGINE MAINTENANCE and gives superior oil filtration at a cost less than 4¢ per 100 miles"

plus 35% more effective cleaning ability than 2nd leading pack!

Leading truck lines select filters for their equipment based on actual results. *Comparison tests* prove DIESELPAK offers 35% to 95% *more* cleaning ability than any substitute pack.

DIESELPAK cleans more oil *faster* and keeps it clean far *longer*. ARE YOU GETTING THE DIESELPAK PROTECTION RECOMMENDED FOR YOUR EQUIPMENT?

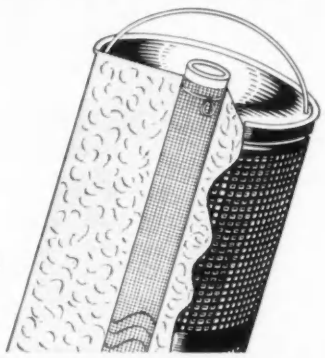
Compare Ringsby experience as reported by Bill Adcock —Supt. of Motor Maintenance—

"—approximately 10,000 miles before we change oil and Dieselpak"

"DIESELPAK is like an insurance policy—assures us of clean lube oil with excellent lubricating qualities for about 10,000 miles"

"Superior oil filtration at a cost less than 4¢ per 100 miles"

Next time you change oil insist on genuine Luber-finer DIESELPAK—get 35% more cleaning ability regardless of conditions.



IT'S WHAT'S INSIDE THAT COUNTS! THERE IS NO SUBSTITUTE FOR DIESELPAK SUPERIOR CLEANING ABILITY

Luber-finer

WRITE TODAY FOR FREE TEST BLOTTERS. Make your own visual comparison of Luber-finer Superior Filtration.

LUBER-FINER, INC.

2514 South Grand Avenue, Dept. F-5, Los Angeles 7, California

DELCO POWER TRANSISTORS

NEW TYPES

MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c = 0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c = 2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

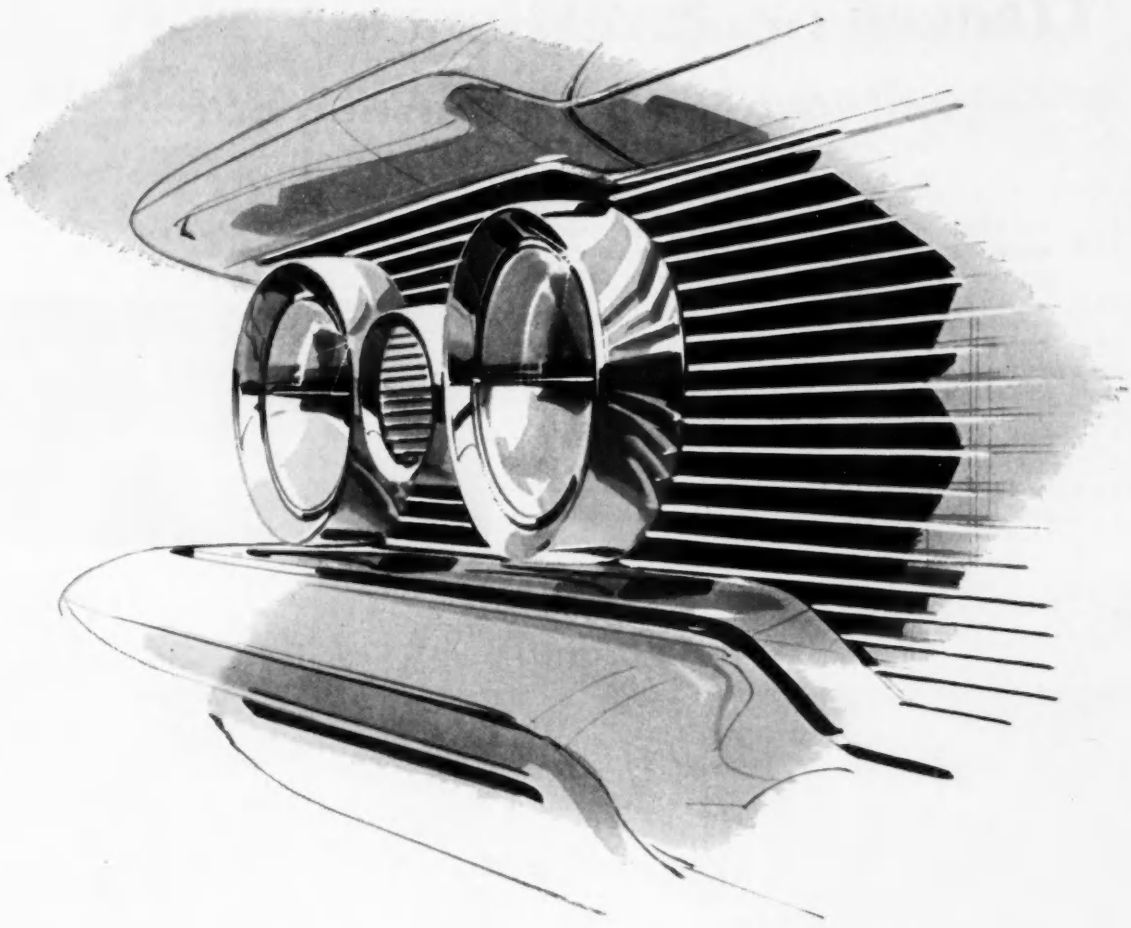
Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

DELCO RADIO
Division of General Motors · Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465



FIRESTONE TURNS ON THE SALES APPEAL WITH *fashionized* ALUMINUM PARTS

Call on the brightest brightwork in the business to put new selling power into your automotive products.

Call on aluminum formed and *Fashionized*® by Firestone to catch your customers' eyes. Call on mass-produced bezels and panels and strips up to seven feet long and shaped with custom quality and character. Call on interior trim textured and tinted to your most meticulous specification.

In short, call on *Fashionized* Aluminum and on Firestone's more than 50 years of experience in the fabrication and finishing of metal. Enjoy every advantage—from competitive capacity to competitive cost—of the industry's finest production facilities. Your inquiries and inspections are cordially invited.

FIRESTONE FASHIONIZED ALUMINUM
FIRESTONE STEEL PRODUCTS COMPANY, AKRON 1, OHIO

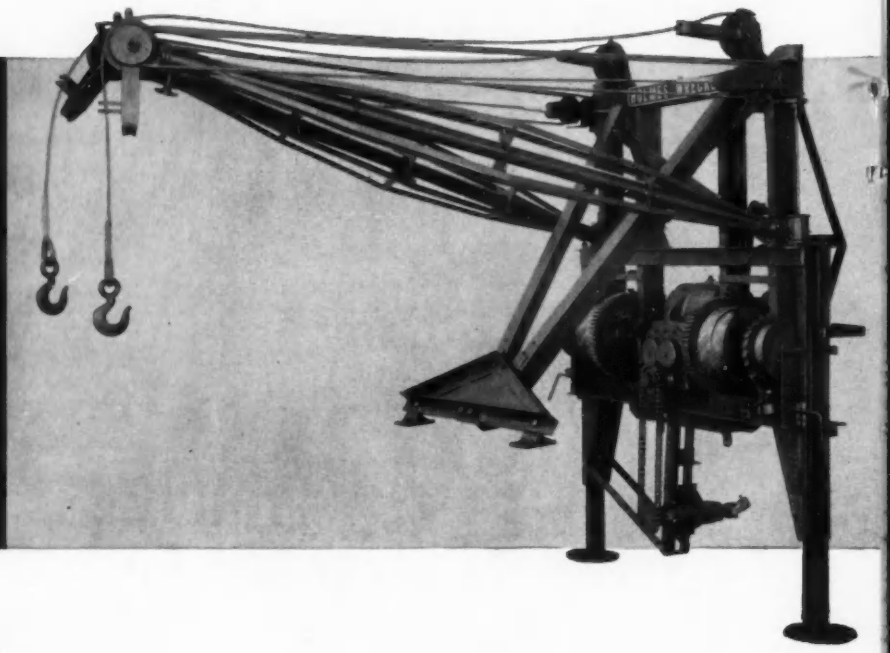
Accent on Excellence

Youngstown cold-finished bars

The *original* automobile wrecker, built many years ago by Ernest Holmes Company of Chattanooga, Tennessee, contained critical components fabricated from Youngstown Cold-Finished Bars. Today, this same high quality steel is being used to build strength into Holmes's up-to-the-minute wrecker designs.

These quality steel bars are drawn to precision tolerances. Finish is uniformly bright and smooth. Both chemical and metallurgical properties are rigidly controlled to meet today's most exacting specifications.

Wherever steel becomes a part of things *you* make, the high standards of Youngstown *quality*, the personal touch in Youngstown *service* will help you create products with an "accent on excellence".



This new model unmounted Holmes wrecker unit provides an over-all lifting capacity of 18,000 pounds. It's shown mounted on a Ford chassis (small illustration) making a wrecker ideally suited for service in congested city areas.

THE
YOUNGSTOWN
SHEET AND TUBE COMPANY
Youngstown, Ohio

Manufacturers of Carbon, Alloy and Yoloy Steel

RCI EPOTUF Epoxy Resin

"An ideal resin for potting applications"

says J. R. McRobert, vice president, Novi Equipment Company

Engine heat, vibration and road shocks present problems that must be met and mastered in auto air conditioning equipment. And the Novi Equipment Company, Novi, Michigan, has found that an RCI EPOTUF epoxy resin plays a vital role in the manufacture of its air conditioners — successfully seals a copper coil component in the steel magnetic compressor clutch — insuring dependable performance.

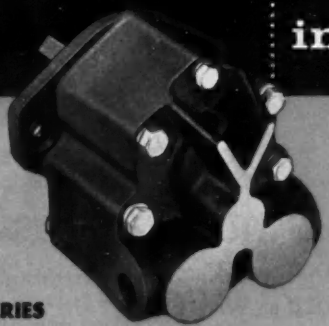
"The use of EPOTUF allows a very close tolerance with a permanent, rigid seal that prevents copper-steel contact — and the 'shorting out' that would thereby result," explains Mr. McRobert. "EPOTUF is the ideal resin for our purposes, possessing excellent qualities of adhesion with the exact electrical properties we require."

Manufacturers everywhere are finding increased use for Reichhold's versatile epoxy resins. EPOTUF epoxies offer rugged strength, corrosion resistance and superior bonding properties that have proven perfect for a variety of applications.

And when you do business with RCI, you can count on fast, on-time deliveries anywhere in the country. Why not let *us* know *your* epoxy requirements?

DYNAMIC DIFFERENCE

in hydraulic performance



"HC" SERIES

POSITIVE DISPLACEMENT GEAR-TYPE PUMP

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5 - 17 gpm
Pressures: to 1500 psi
Operating speeds: to 2400 rpm
Porting: side (Std.) end (Opt.)
Valve: Optional; internal relief, adjustable 800 - 1500 psi

BULLETIN HY11 gives complete engineering characteristics — performance and installation data.

Call the man from Webster

. . . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

photo: Baker Industrial Trucks, div. of Otis Elevator Co., Cleveland, O.

Webster

POSITIVE DISPLACEMENT GEAR-TYPE PUMPS

Yesterday's pipe dream is today's nimble-fingered reality. This versatile fork lift truck unloads and stacks — carries a full platform load. The heart of its powerful hydraulic system is a Webster Gear-Type Pump. Just another example of Webster's practical and economical adaptation to hundreds of hydraulic applications . . . in lift systems, pressure lubricating, oil circulating . . . in industrial, agricultural and construction equipment.

Webster Gear-Type Pumps present many advantages in design "fit" and application — with unusual standardization and interchangeability of components. Keep Webster in mind when you plan hydraulics — for the dynamic difference that pays!

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

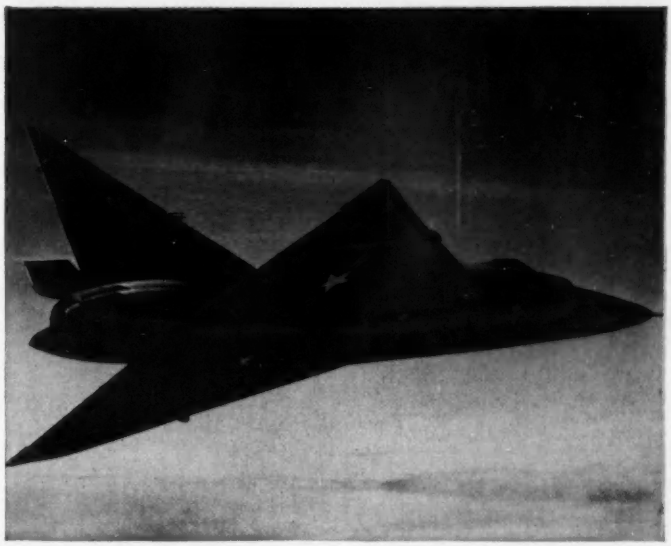
RACINE · WIS

our 50th year

franklin adv. H-113

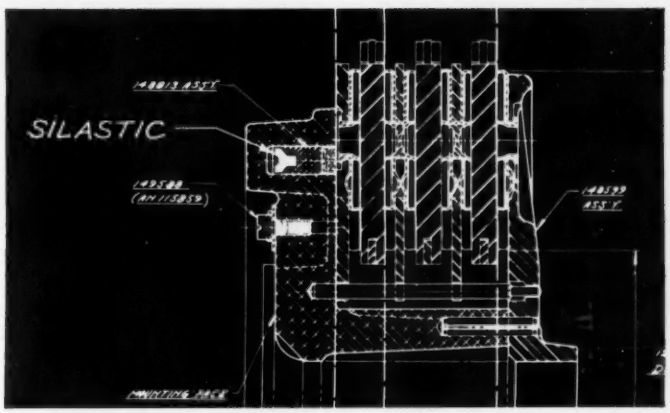
The PLANE

Convair's F-102A "Delta Dagger" Air Force all-weather interceptor. The F-102A incorporates both delta wing and NACA "area rule" fuselage design for supersonic regime flight. A single seat, single-engined turbojet, it normally carries both air-to-air guided missiles and secondary rocket armament.



The PROBLEM

Brake gaskets on the F-102A's landing gear. These gaskets are in direct contact with the brake drums. They must be strong, must remain resilient, and must keep their shape under pressure, despite high temperature developed during braking.



The PART

SILASTIC

SILICONE RUBBER

Because neither the pressure nor the intense heat affects Silastic®, the Dow Corning silicone rubber, Convair has specified it for the F-102A's brake gaskets.

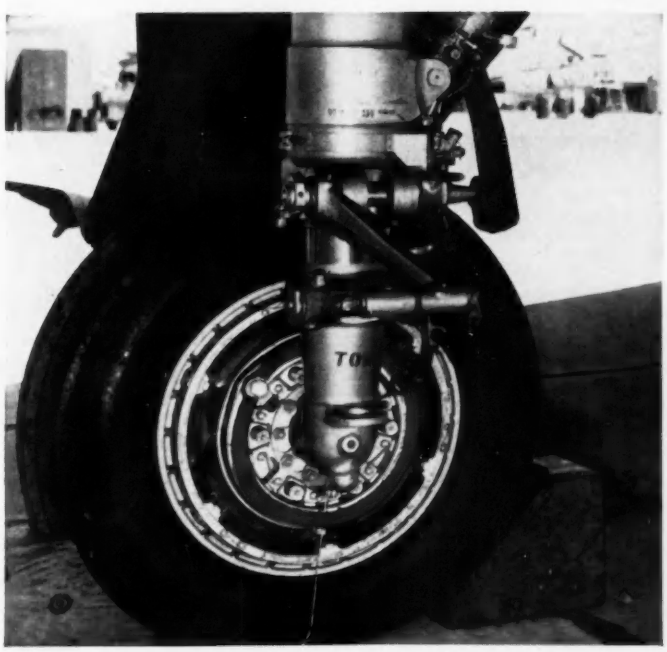
TYPICAL PROPERTIES OF SILASTIC FOR GASKETS

Temperature range, °F	—130 to 500
Tensile strength, psi	600 to 1400
Tear strength, lb/in	40 to 200
Compression set, %, @ 300 F	5 to 40

For further details, write Dept. 9116.

first in silicones

Dow Corning
CORPORATION
MIDLAND, MICHIGAN



+ INDEX TO ADVERTISERS +

No matter where it's bought...

Its performance and name are the same around the world

Shell Rimula Oil is available to your customers abroad. They can depend upon it for the most severe conditions of diesel operation.

Rimula® Oil is a heavy-duty oil designed to solve the toughest lubricating problems in diesel engines.

One of these problems—excessive cylinder and ring wear—results from acidic combustion products. It occurs under all operating conditions, but is especially severe under low jacket temperatures. Rimula Oil contains an alkaline additive that counteracts this acid wear. It remains stable under the widest temperature extremes encountered in modern diesel operation. It keeps engine parts clean and operating efficiently over longer periods . . . effecting worth-while savings in labor and parts.

For full information, write Shell Oil Company, 50 West 50th Street, New York 20, N.Y., or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

Other outstanding Shell Industrial Lubricants

Shell Tellus Oils—for hydraulic systems

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metalworking

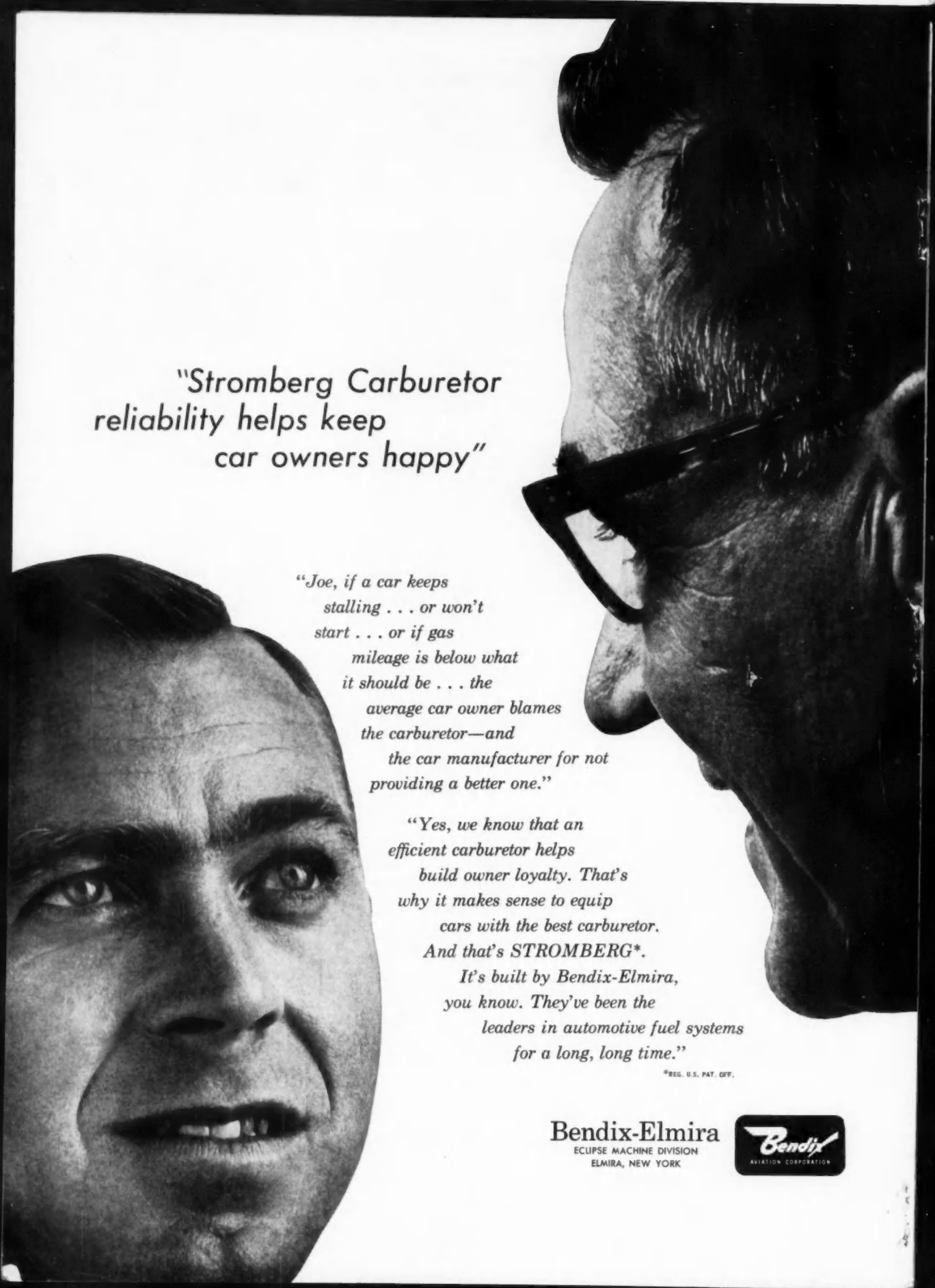
Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

SHELL RIMULA OIL

the heavy-duty crankcase lubricant

SHELL



"Stromberg Carburetor reliability helps keep car owners happy"

"Joe, if a car keeps stalling . . . or won't start . . . or if gas mileage is below what it should be . . . the average car owner blames the carburetor—and the car manufacturer for not providing a better one."

"Yes, we know that an efficient carburetor helps build owner loyalty. That's why it makes sense to equip cars with the best carburetor. And that's STROMBERG. It's built by Bendix-Elmira, you know. They've been the leaders in automotive fuel systems for a long, long time."*

*REG. U.S. PAT. OFF.

Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, NEW YORK

Bendix
AVIATION CORPORATION

BUDD AND PROGRESS...
in a progressive age

The Defense Division of The Budd Company is currently making major contributions to the development of jets, rockets and missiles. Shown above is a jet afterburner.

The International Division of The Budd Company has spread throughout the globe. Eleven European automobile manufacturers and body suppliers are under license to employ Budd patents and manufacturing methods.

This is The Budd Company.

One of America's great industrial enterprises.

Ten plants and 35 offices coast to coast.

Investments, subsidiaries and licensees around the world.

Thirteen employees in 1912.

Average employment today, 14,000.

Engineers, designers, technicians, research experts.

1958 payroll and employee benefits approximated: $125,000,000.

This is progress in a progressive age.

This is Budd . . . today!

THE BUDD COMPANY
Philadelphia 32, Pa.

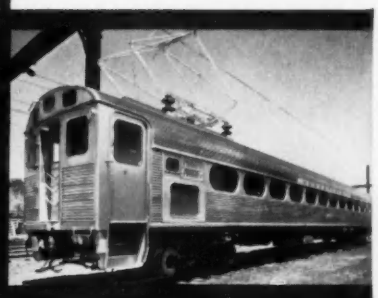
Budd

Continental-Diamond Fibre Corporation, a subsidiary of The Budd Company, has been a pioneer in the development and manufacture of laminated and molded plastics, vulcanized fibre and bonded mica in the forms of sheets, rods, and tapes.

Tatnall Measuring Systems Company, a subsidiary of The Budd Company, develops, manufactures and sells a complete line of modern physical testing equipment such as this PhotoStress machine.

The Nuclear Systems Division of The Budd Company manufactures and sells industrial radiography equipment; it stores and markets radioisotopes; it designs and markets radiation facilities.

The Automotive Division of The Budd Company produces automobile and truck body components, chassis frames, wheels, hubs and brake drums. All major car and truck manufacturers are customers of Budd.



The Railway Division of The Budd Company has pioneered, developed and built a wide variety of all types of railway cars. Above is a stainless steel, air conditioned, electrically propelled commuter car.

52100

HARD, TOUGH, EASY TO MACHINE FOR TRICKY SHAPES

WORKHORSE parts like those pictured above have to be tough and hard for the jobs they do. But their intricate shapes demand a steel that's easy to work.

Timken 52100 steel meets every specification for this kind of flexibility. It's a high-carbon alloy steel with high fatigue and tensile strength plus good hardenability throughout its cross section. It machines easily, yet the steel's fully spheroidized structure retains full strength and hardenability.

Working pressures up to 200,000 p.s.i. are easily withstood by Timken 52100 steel. It will oil quench to a maximum hardness of 65/66 Rockwell C in normal sections.

Uniformity from shipment to shipment is assured, too, because high Timken Company standards control quality from melt shop to final inspection.

Timken pioneered 52100 tubing in America. Today, as the only U.S. source for 52100 steel in tubing, bar and wire, we continue as one of the world's largest producers of this versatile alloy.

And for small runs or emergency requirements, we maintain a mill stock of 52100 tubing in 101 sizes from 1″ to 10½″ O.D. Write today for a complete stock list of available sizes, grades and finishes. The Timken Roller Bearing Co., Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING